VALIDITY OF A SELF-REPORTED "VITAL SIGN" FOR PHYSICAL ACTIVITY IN ADULTS OF PRIMARY HEALTHCARE

by

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STATEMENT OF DISSERTATION APPROVAL

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ABSTRACT

Few instruments have been developed to assess patient physical activity (PA) in primary healthcare, nor assessed for validity. The purpose of these studies was to provide evidence of validity for a PA "vital sign" (PAVS) self-reported by clinic staff and patients and for the PA portion of the Speedy Nutrition and PA assessment (SNAP). Criterion validity of the PAVS and SNAP was assessed in clinic staff by agreement with accelerometry (accel). Construct validity of the PAVS was assessed by using electronic health records (EHRs) to examine odds of BMI and Charlson Comorbidity Index categories for patients reporting to the PAVS as not meeting *2008 Aerobic PA Guidelines for Americans* (PAG) compared to patients meeting PAG. Concurrent validity of the PAVS was assessed by associating patient responses to the PAVS with concurrent responses to a Modifiable Activity Questionnaire (MAQ).

The PAVS and SNAP correlated moderately strongly with accel identifying days/week clinic staff (N = 45) achieved ≥30 minutes (min) of moderate-vigorous PA (MVPA) performed at least 10 min. at a time (PAVS, r 0.52, $p < 0.001$; SNAP, r 0.31, $p < 0.05$). Of 34,712 eligible outpatient visits, patients who did not meet PAG according to the PAVS were more likely than normal weight patients to have a higher BMI (BMI 25.0-29.9, OR = 1.19, $p = 0.001$; BMI 30-34.9, OR = 1.39, $p < 0.0001$; BMI 35.0-39.9, OR = 2.42, $p < 0.0001$; BMI ≥ 40, OR = 3.7, $p < 0.0001$). Likewise, patients who did not meet PAG were also significantly more likely to have a higher disease burden (above 50^{th} Charlson percentile, OR = 1.8, $p < 0.0001$). Of 269 eligible patient-participants, the PAVS agreed with the MAQ 89.6% of the time identifying insufficiently active patients and demonstrated good agreement with the MAQ identifying patients meeting/not meeting PAG (k = .55, rho = 0.57; $p < 0.0001$). Usual $\text{min}\cdot\text{wk}^{-1}$ MVPA reported to the PAVS correlated strongly with the same construct reported to the MAQ ($r = 0.71$; $p < 0.0001$).

The PAVS appears to be a useful and valid tool particularly for identifying patients who most need counseling for PA. The PAVS should be evaluated further for validity and repeatability with

criterion measures of PA. The PAVS could be used within EHRs to improve estimates of PA-disease relationships and interventions aimed to improve patient PA.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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CHAPTER 1

INTRODUCTION

Statement of the Problem

Few instruments have been developed to assess patient physical activity (PA) in primary healthcare. In order for instruments to be used with confidence by primary healthcare providers, the validity of the instruments must be established in the patient population. Few instruments that assess patient PA have been assessed in the primary healthcare patient population.[1-3] Only one of these instruments has been assessed for its ability to identify patients not meeting adult *2008 Aerobic PA Guidelines for Americans* (PAG) of the U.S. Department of Health and Human Services (DHHS).[2] These studies aimed to provide evidence of validity for a physical activity “vital sign” (PAVS) and the PA portion of the Speedy Nutrition and PA assessment (SNAP) that are each brief primary care self-report assessments of patient PA. The PAVS is currently used regularly at Intermountain Healthcare clinics in the Salt Lake Valley.

Importance of the Problem

The primary healthcare setting is increasingly being recognized as a critical environment for improving population PA.[4-7] The first step for treating physical inactivity through primary healthcare is to assess levels of PA of patients. The most feasible current method of assessing patients’ PA in a primary healthcare setting is by self-report.

The validity of self-reported PA in primary healthcare settings has significant public health implications. Valid measures of PA in primary healthcare will be particularly valuable when investigating relationships between PA and health. Investigating these relationships becomes feasible when PA assessment becomes a standard part of patient electronic medical records (EHRs). Developing valid measures of PA for primary healthcare will also be important for assessing the effectiveness of clinical interventions aimed at treating physical inactivity and morbidity associated with physical inactivity.[1,3,4,7]

Current self-report measures of PA attenuate significantly observed epidemiological relationships between PA and health in study samples representative of the United States.[8-9] Assessing and improving the validity of population measures of PA, which is now including primary healthcare PA assessments recorded in EHRs, will lead to better estimates of epidemiological relationships between PA and health. These improved observed relationships have the potential to facilitate changing policy and PA interventions in healthcare. Assessing the validity of self-report measures of PA is consequently becoming a public health priority.[9-10]

Overview of Important Literature

Physical inactivity is a leading cause of illness and premature death.[11] It has been considered the biggest public health problem of the 21st century because of the number of deaths that would be avoided in the absence of low cardiorespiratory fitness as a risk factor that noticeably exceeds other leading risk factors.[12] The primary healthcare setting is being increasingly recognized as a critical environment to improve population PA.

A primary healthcare *provider* is an individual that provides medical or health services in primary healthcare. This includes, to the extent of the studies involved herein, medical doctors, doctors of osteopathy, nurse practitioners, and physician assistants.[13] Information given by primary healthcare providers is more trusted by patients than information given by other health professionals.[14] This may be because primary healthcare providers are seen frequently and regularly and because other behavioral health interventions have been successful in primary healthcare.[4-6,15]

Numerous organizations recommend counseling for PA in primary healthcare. These include the U.S. Preventive Services Task Force (USPSTF), the American Heart Association (AHA), the American College of Sports Medicine (ACSM), and the American College of Preventive Medicine.[4,16-17] In their 2010 review of PA and healthful eating behavioral counseling interventions in primary healthcare, the USPSTF found small but statistically significant reported changes in PA from PA interventions that require little time and few resources.[4] Valid and reliable PA questionnaires are thus particularly important when changes in behavior are likely to be relatively small but practically meaningful from a population and public health perspective.

Methods of establishing valid and reliable measures of PA, as a growing public health priority, are evolving steadily.[9,18] A *valid* instrument measures accurately what it intends to measure. A *reliable* instrument measures consistently, or dependably, when administered to the same individual over time or by different administrators. There are currently numerous methods for evaluating the validity and reliability of PA assessment instruments.[19] It is sensible to evaluate first the *validity* of an instrument because a PA assessment instrument can be *reliable* without being *valid* (ie, it can consistently assess PA inaccurately).

There are several types of validity for PA assessment instruments, each with its own relevance and value.[20] This study will evaluate evidence specifically for *construct* and *concurrent* validity of the PAVS. Construct validity refers to the outcome of an assessment being correlated with factors that, in theory, should be related to the outcome. In this case, the PAVS intends to assess typical PA, which based on literature, should be related to numerous health measures.[16,19] For example, body mass index (BMI), blood pressure, and fasting blood glucose are inversely related to PA in adults.

Establishing construct validity in this study by relating PA to health outcomes is very important to primary healthcare providers because this helps them determine if a vital sign is helpful in understanding a patient's overall health status. Without construct validity, it is difficult for an assessment such as the PAVS to be accepted and adopted by primary healthcare providers as providing meaningful, actionable information regarding behavior and health. Aim 1 of these studies will address the construct validity of the first of two versions of the PAVS (see Figure 1.1).

Concurrent validity refers to how well an assessment agrees with another assessment designed to measure the same construct that already has well established validity. In this study, outcomes assessed by a second version of the PAVS will be compared to the outcomes assessed by a Modifiable Activity Questionnaire (MAQ) to determine the extent to which these outcomes correlate and agree with each other. A MAQ is "modifiable" because it queries only activities identified as commonly performed by the population of a study responding to the MAQ.

A systematic approach was used to choose the MAQ for evaluating concurrent validity of the PAVS, following steps recently developed by Sternfeld and Goldman-Rosas.[21] The MAQ has the strongest established validity among PA assessment instruments that measure the same PA constructs as the PAVS.[22-24] In a recent systematic review of PA questionnaires evaluated against objective criteria, the MAQ correlated most strongly with objective measures by accelerometry of weekly moderate-vigorous PA (MVPA).[23] One possible reason for why the MAQ correlates strongly with objectively measured MVPA is the MAQ queries only MVPA and does so using the most common activities identified by focus groups representative of the study population.[22,24] The MAQ that will be used in this study includes activities most commonly performed according to Utah physical activity responses to the 2012 Behavioral Risk Factor Surveillance System (see Appendix A).[25]

Others have suggested that assessing construct and concurrent validity of a PA assessment instrument is a prudent first step in evaluating evidence of validity for any PA assessment instrument.[2-3,26] It would be desirable to also assess *criterion* validity of the PAVS by providing evidence of agreement between the PAVS and an objective measure of energy expenditure such as doubly labeled water or with an objective measure of MVPA such as with accelerometry. However, the resources required for evaluating criterion validity of the PAVS were not available for this study and therefore not feasible. Future research should assess criterion validity of the PAVS. Evaluating evidence of construct and concurrent validity of the PAVS that is administered regularly to primary healthcare patients is of great value to the clinics where the PAVS is regularly administered.

Self-report measures of physical activity used in primary healthcare are unique from other, more common, physical activity questionnaires. Physical activity assessed in primary healthcare needs to be quicker than most PA assessment instruments because of high demands on time in the primary healthcare setting. To accommodate this demand it is important for primary healthcare physical activity assessment instruments to include only a couple of questions.[2] The PA questions also need to be easy to understand by diverse groups of patients. Existing PA assessment instruments used in primary healthcare are too long and complex and do not include data to assess whether patients comply with current aerobic PAG that facilitate identifying patients that most need PA counseling.[3,27-29] The current PAG recommend that in order to maintain and promote health, adults should accumulate a minimum amount of weekly aerobic PA by at least one of three ways: 1) at least 150 mins·wk^{-1} of moderate-intensity PA, or 2) 75 mins·wk^{-1} of vigorous-intensity PA, or 3) an equivalent combination of 150 mins·wk^{-1} of moderate to vigorous intensity PA (MVPA).[30]

Only a few PA assessment instruments used in primary healthcare have been evaluated for their utility and validity. Glasgow and colleagues did not consider any self-report PA questionnaires practical to implement in primary healthcare in their 2005 review of patient self-reported measures of health behaviors.[27] Their main finding was that PA questionnaires took too long to complete. The shortest primary healthcare PA assessment instrument published to date includes the two- and three-question PA questionnaires evaluated by Smith et al.[3] (no names for these questionnaires are provided in literature), the Exercise Vital Sign,[2] the PAVS, and the PA component of the Speedy Nutrition and Physical Activity Assessment (SNAP).[31] The PA questionnaires evaluated by Smith et al. require a median of 1-2 minutes to complete, and the Exercise Vital Sign, the PAVS, and the PA component of the SNAP each require a mean of <1 min to complete. The Exercise Vital Sign demonstrated strong discriminant validity with patient health data in EHRs, but has not been evaluated against other measures of PA, concurrently with another PA questionnaire or with an objective measure of PA. The two-question PA assessment instrument evaluated by Smith et al. demonstrated poor agreement with sufficient activity measured by accelerometry (37.3%) and moderate agreement identifying insufficient activity according to accelerometry and PA guidelines of the ACSM/AHA (79.9%). The PAVS demonstrated preliminary evidence of agreeing highly with identifying respondents that were insufficiently active according to aerobic PA guidelines of the ACSM/AHA (90.7%). The PAVS also agreed moderately with number of days respondents performed ≥30 minutes of moderate-vigorous intensity PA by accelerometry (r = 0.52; kappa = 0.46).[31] The PAVS needs to be assessed for validity now that it is administered regularly in primary care clinics.

The Physical Activity "Vital Sign"

The PAVS is a brief (<30 s) self-report assessment of patient PA. It was created by a primary healthcare provider at Intermountain Healthcare. Intermountain Healthcare, Inc. is a nonprofit healthcare system of 22 hospitals and approximately 160 healthcare facilities, headquartered in Salt Lake City, UT. Intermountain employs 33,000 people. The PAVS was integrated into Intermountain Healthcare's ambulatory EHR in February 2013 and has been administered regularly for at least 1 year to patients served at three Intermountain Healthcare primary care clinics. At the clinics where the PAVS is known to be administered regularly, it is administered to every patient at each patient visit when they check in for appointments or during the same time other vital signs are measured.

Two versions of the PAVS have been used in these clinics (see Figure 1.1). The first version of the PAVS, or the way the PAVS was worded when first implemented into regular clinical practice, asked two questions to patients: (1) "On average, how many days per week do you participate in moderate or greater physical activity (like a brisk walk)?" followed by (2) "On those days, how many minutes do you participate at that level?" Wording of the PAVS was changed in 2013 to reflect meeting aerobic PAG[30] in contrast to the ACSM/AHA PA guidelines assessed by the first version of the PAVS.[16,31] The second and most current version of the PAVS asks patients upon checking in for their appointment to report to three questions on paper that intend to assess usual $mins \cdot wk^{-1}$ of PA done at either light, moderate, or vigorous intensities. The PAVS asks (1) "Please describe your level of physical activity by minutes per day" and (2) by "number of days each week" followed by (3) "at what intensity (how hard): light (like a casual walk), moderate (like a brisk walk), or vigorous (like a jog/run)?"

Similar to other vital signs, the PAVS is embedded in the computer software platform that manages patient electronic health records (EHRs) at Intermountain Healthcare, called HELP2. Medical assistants, or other providers, enter responses to the PAVS into HELP2. The first version of the PAVS was recorded in EHRs for patients treated at the Intermountain Healthcare Memorial Internal Medicine clinic November 2011-November 2013. Currently, only the second, most recent version of the PAVS used by Intermountain Healthcare is recorded in patient EHRs. The medical assistants first enter the intensity of PA reported by patients, followed by number of days per week and minutes per day. Total mins·wk^{-1} of PA that were reported by the patient as “light,” “moderate,” or “vigorous” are automatically calculated by the EHR by multiplying average minutes/day of PA by average days/week of PA. MVPA is automatically calculated by summing mins·wk^{-1} of “moderate” and "vigorous" PA. According to PAG, patients are considered insufficiently aerobically active if they report less than an equivalent combination of 150 mins·wk^{-1} of MVPA.[30] The PAVS and HELP2 determine the average mins·wk^{-1} patients perform MVPA and if they are sufficiently active according to aerobic PAG.

Public health PAG include muscle-strengthening activity in addition to the aerobic activity guidelines examined by the PAVS. Assessing muscle-strengthening activity of patients has not been developed to the same extent as assessing aerobic PA. Assessing muscle-strengthening PAG with patients was not addressed in these studies because developing instruments for assessing PA in primary healthcare is still new and focusing its development first on aerobic PA because of aerobic activity’s greater currently known relationships with health.[32]

The first version of the PAVS demonstrated construct validity by associating strongly with patients’ BMI in a moderate sample size (N = 261), and also showed preliminary evidence of agreeing with MVPA measured by accelerometry.[7,31] Findings of the latter study were limited by a small and homogenous sample of subjects. Validity of the first version of the PAVS needs to be assessed after having been recorded in EHRs in clinics where this version of the PAVS was administered regularly. Validity of the second and current version of the PAVS needs to be assessed for the first time where it is also currently administered regularly to a patient population of a clinic.

Research Aims and Hypotheses

The validity of the PAVS has not been assessed since it became a regular part of clinical practice at two Intermountain Healthcare clinics starting in November 2011 with the first version of the PAVS and in November 2013 with the second version of the PAVS. There were three primary aims of these studies. The first aim was to assess criterion validity of the PAVS and PA portion of the SNAP by accelerometry in clinic staff. The second aim was to assess construct validity of the first version of the PAVS (see Figure 1.1) by associating patient responses to the PAVS with health data from patient EHRs. This was done by assessing the probability (ie, odds) of patients that reported to the PAVS as not meeting PAG having a higher BMI and disease burden compared to patients that reported to the PAVS as meeting PAG. The third aim of these studies was to assess concurrent validity of the second version of the PAVS (see Figure 1.1) with patient responses to a MAQ. A secondary aim included examining differences in the concurrent validity of the PAVS in Aim 2 according to how confident patients felt they were able to report their PA to the PAVS.

For primary Aim 1, I hypothesized that the PAVS would correlate moderately-strongly with accelerometry identifying days/week clinic staff performed 30 or more mins/day of MVPA and that the PA portion of the SNAP would correlate moderately with accelerometry.

For primary Aim 2, I hypothesized that patients who reported to the PAVS as not meeting aerobic PAG of getting at least 150 mins·wk^{-1} of MVPA would have higher odds of having higher BMI and disease burden compared to patients that reported to the PAVS as meeting PAG.

For primary Aim 3, I hypothesized that mins·wk^{-1} of MVPA reported to the PAVS would agree moderately with mins·wk^{-1} of MVPA reported concurrently to the MAQ. For my secondary Aim (3a), I hypothesized that mins·wk^{-1} of MVPA reported to the PAVS would agree most strongly with mins·wk^{-1} of MVPA reported concurrently to the MAQ in patients who would feel most confident compared to those who feel less confident, reporting their PA to the PAVS. Confidence ratings reported to the PAVS were dichotomized into *high* and *low* confidence groups according to the median reported confidence rating.

Methods

These studies were approved by the Institutional Review Boards of The University of Utah and Intermountain Healthcare.

Aim 1: To Assess Criterion Validity of the PAVS

These studies first aimed to assess criterion validity of the PAVS and the PA portion of the SNAP with staff employed at health clinics of The University of Utah and Community Health

Clinics. The version of the PAVS assessed by Aim 1 asked clinic staff two questions designed to assess their typical and past-week levels of MVPA: 1) “How many days in the past week have you performed PA where your heart beats faster and your breathing is harder than normal for 30 minutes or more? (in 3, 10 minute bouts, or 1, 30 minute bout)” followed by 2) “How many days in a typical week have you performed activity such as this?”

Participants

Eligible participants of this study included adult clinic staff that were generally healthy. Clinic staff were chosen in order to help familiarize clinic staff with the PAVS and the SNAP that were currently being incorporated into regular clinic practice.

Procedures

Participants wore an accelerometer around their hip for 7 consecutive days and afterwards responded to the PAVS and SNAP. Data from accelerometers were used to estimate days each participant performed at least 30 minutes of MVPA done at least 10 minutes at a time and also not done at least 10 minutes at a time.

Analyses

Criterion validity of the PAVS was assessed primarily by a Pearson correlation coefficient between accelerometry and responses to the PAVS identifying days during the past week participants performed at least 30 minutes of MVPA by 10-minute bouts. Criterion validity of the PA portion of the SNAP was assessed primarily by Spearman’s rank correlation coefficient between accelerometry and responses to the SNAP that categorically identified days participants performed at least 30 minutes of MVPA by 10-minute bouts.

Aim 2: To Assess Construct Validity of the PAVS

These studies aimed secondly to assess construct validity of the first version of the PAVS used by Intermountain Healthcare by associating patient responses to the PAVS with a retrospective cross-section of adult health data from patient EHRs. The version of the PAVS that was assessed by Aim 2 asked two questions between November 1, 2011, and November 1, 2013, to assess patient PA: (1) “On average, how many days per week do you participate in moderate or greater physical activity (like a brisk walk)?” followed by (2) “On those days, how many minutes do you participate at that level?” Days per week were multiplied in HELP2 by minutes per day to estimate total mins·wk^{-1} of MVPA. To assess evidence of construct validity of the PAVS, or validity with indirect traits of PA, patient responses to the PAVS as meeting or not meeting PAG were regressed in logistic models against patient BMI and disease burden recorded in the same patients’ EHRs.

Disease burden was measured by the Charlson Comorbidity Index.[33] This index summarizes a patient’s risk for 10 years of mortality based upon 17 different health conditions, or comorbidities, and is autocalculated from health conditions recorded in patient EHRs. The Charlson Comorbidity Index has a strong degree of direct validity and reliability, and as such, is used widely to evaluate indirect validity of other health data in adult patient EHRs.[34] Associations between patient PA reported to the PAVS and the Charlson Comorbidity Index were calculated because of known independent associations between physical activity, morbidity, and mortality.[16,19,32,35]

Participants

Eligible participants for Aim 2 were generally healthy men and women 18 years and older who were patients treated at Intermountain’s Memorial Internal Medicine Clinic between November 1, 2011, and November 1, 2013. Data from the EHR were analyzed from only this clinic because it was the first to administer the PAVS, beginning November 1, 2011, and the only clinic to have administered the PAVS regularly for at least 1 year. This time period was chosen in order to include all patients’ first response to the PAVS and across each season of 2 years to control for seasonal variation in PA and health data recorded in the EHR.

Certain clinical conditions caused patient data to be excluded from Aim 2 in order to avoid confounding relationships between PA reported to the PAVS and patient body weight that was examined as part of Aim 2. These conditions included ever having bariatric surgery or hyper- or hypothyroidism or being pregnant and during the study timeframe having an eating disorder or being prescribed atypical neuroleptics. Data from patients who were ever diagnosed with dementia or whose preferred language was not English were excluded because the PAVS required patients to cognitively recall PA and because the PAVS was administered only in English during the study timeframe.

Procedures

Aim 2 examined a retrospective cross-section of patients from Intermountain's Memorial Internal Medicine Clinic. Strategies for acquiring EHR data for the outcomes of Aim 2 were based on best practices currently performed through the Intermountain Healthcare Office of Research. The following elements were used in Aim 2 to assess construct validity of the PAVS with patient health data from EHRs:

1. Charlson Comorbidity Index (ordinal)
2. BMI ($kg \cdot m^{-2}$)
3. Age (years)
4. Gender (binary)
5. PAVS
    a. Self-reported average number of days per week "participat[ed] in moderate or greater physical activity (like a brisk walk)"
    b. Self-reported number of "minutes participat[ed] at that level
    c. The product of a. and b. as average $mins \cdot wk^{-1}$ of MVPA

Analyses

Descriptive statistics were calculated for the health data from the EHRs of patients who completed the PAVS version 1. Data from the internal medicine clinic were pooled for analyses. To examine Aim 2 and construct validity between the PAVS and health data from EHRs, the PAVS was regressed in multivariate logistic models to determine if patients who reported to the PAVS as not meeting aerobic PAG were more likely to have higher BMI and disease burden compared to patients who reported to the PAVS as meeting PAG. Separate models were used for BMI and for disease burden. The adequacy and fit of each model were tested using Pearson chi-square and deviance statistics to test differences between observed and fitted values. Fitting models was optimized by adjusting for demographic variables. BMI was automatically calculated by HELP2 from height and weight recorded in EHRs using the equation [height (inches) ÷ weight^2 (pounds)] X 703.[36] Figure 1.2 illustrates the general notation used with each logistic regression model.

Aim 3: To Assess Concurrent Validity of the PAVS

This study aimed to assess concurrent validity of the second version of PAVS used by Intermountain Healthcare with concurrent responses to a population-specific MAQ. The second version of the PAVS includes three questions recorded by patients on paper while checking in for their appointment (see Figure 1.1): (1) "Please describe your level of physical activity: [first by] minutes per day" followed by (2) "number of days each week" and (3) "at what intensity (how hard): light (like a casual walk), moderate (like a brisk walk), or vigorous (like a jog/run)?"

A secondary aim (Aim 3a) examined differences in the concurrent validity of the PAVS in Aim 3 according to how confident patients felt they were able to respond to the PAVS. Studies have found that self-reported health behaviors are more accurate when respondents have greater confidence in reporting behaviors.[26,37] Measuring confidence in ability to recall PA for the PAVS can help identify measurement error attributed to confidence in ability to recall PA. Identifying this measurement error can be highly useful in several ways. Identifying this measurement error could improve the accuracy of the PAVS when the PAVS is used to investigate epidemiological relationships between PA and health, be used for improving PA questionnaire items and wording, and assist with better identifying relative recall accuracy of the PAVS.[26,38-40] Therefore, all participants of Aim 3 were asked to report how confident they felt reporting their PA levels to the PAVS.

Participants

Eligible participants for this study were generally healthy men and women 18 years and older who were patients at Intermountain Healthcare's Avenues and Memorial internal Medicine clinics or at Memorial's primary care clinic. These clinics were chosen because they were the only Intermountain clinics regularly administering the PAVS at the anticipated start of this study.

Patients with dementia or who did not speak English were excluded from participating in this aim because the PAVS requires patients to recall PA and because the PAVS is currently administered regularly in English only.

Aim 3 was estimated to require 322 patient-participants (N = 268 for adequate study power + 20% subject attrition = 322 minimum). Collecting this many questionnaires from participants was estimated from prior experience to require 14-18 weeks (32 total hours per week recruiting participants in 2 clinics at 18-23 participants per week). The number of participants required was determined by a power analysis for an estimated Cohen kappa statistic of categorical agreement between the PAVS and MAQ.[41] Accordingly, sample size was determined by an expected Cohen's kappa statistic for interrater agreement between the PAVS and MAQ of 46%, a 33% proportion of positives by the PAVS, 50% proportion of positives by the MAQ, and a 95% confidence interval of 10%. An expected Cohen's kappa of 46% and the proportion of positives for each questionnaire were conservative estimates of agreement between the questionnaires and a criterion measure of PA found from a previous pilot study that examined criterion validity of a previous version of the PAVS with accelerometry.[31]

Recruitment and Procedures

All recruitment strategies used for this aim were based on best practices currently performed at Intermountain clinics through the Intermountain Healthcare Office of Research Clinical Trials. Approval to recruit patients to participate was sought from the Avenues and Memorial clinic medical directors and clinic providers. In order for the clinic providers to familiarize themselves with the procedures of this study, the providers at these clinics were given a copy of the study protocol, the MAQ, and participant consent/information form before meeting with the researchers.

Following approval by clinic providers, eligible patients were recruited in person by medical assistants (MAs) during prescheduled patient appointments. Researchers made every effort to work closely with MAs in order to recruit in ways that would minimize disrupting patient workflow in the clinics. MAs recruited as many eligible patients as possible to participate after checking patients into their exam room and assessing the patient's vital signs. MAs recruited eligible patients by asking, "Will you please take 5 minutes after your exam today to answer a few questions that will help us improve our patient care?" Physical activity was specifically not mentioned by MAs at this point in recruiting participants in order to reduce bias in the sample of patients that would participate. This was intended to help the sample of participants be more representative of patients' physical activity levels. MAs were provided index reference cards that included their recruitment question in order to help control recruitment bias. MAs referred questions from patients to research assistants waiting in a nearby exam room. Patients who were interested in participating were given a small piece of paper that reminded them to remain in their exam room after their exam for an MA to escort them to another private exam room and research assistant. MAs were also provided a similar piece of paper to give to the provider of each interested patient that reminded the provider to remind the patient after the patient exam to wait in their exam room for an MA to escort them to another private room to meet with the research assistant.

After describing the study to interested patients in a private exam room, research assistants provided participants a study information sheet that included details of the study and persons to contact for questions or concerns. This study had minimal risk and gained approval from the Institutional Review Boards of Intermountain Healthcare and The University of Utah for an authorization of waived consent. This study was designated as minimal risk because no personal identifiable information was collected from participants. Research assistants administered the MAQ after describing the study (see Figure 1.3). One question was added to the MAQ that asked participants on a scale of 1-5 how confidant they felt reporting their PA to the PAVS when checking in for their appointment that day. This added question was modified from previous studies that also examined the influence of confidence in ability to recall health behaviors, including PA, on self-reported health behaviors.[26] Patients were recruited to participate continually by MAs until a minimum number of patients participated for adequate study power (N = 268). There was no reason to think that patients at participating clinics were significantly distinguished by days or times of their appointments.

Analyses

To help assess how well the volunteer participants in this study represented the total eligible participants within participating clinics, proportions of gender and age groups between participants and eligible participants were compared using two-sample tests of proportions. Other descriptive data of eligible participants were not available for analysis.

Correlation and agreement were tested between mins·wk^{-1} MVPA reported to the PAVS and mins·wk^{-1} MVPA reported to the MAQ. Correlation and agreement between the two PA assessment instruments were tested only for patients who indicated that PA reported to the MAQ was “usual” for them because the PAVS assesses usual activity. Participants who indicated that PA reported to the MAQ was not “usual” for them were excluded from all analyses. Because PAG can be met by accumulating an “equivalent [weekly] combination” of MVPA, minutes performing activities included in the MAQ that were of vigorous intensity, compared to moderate, were weighted twice when summing total usual mins·wk^{-1} MVPA for participants (see DHHS, 2008). Activities included in the MAQ were identified as vigorous or moderate according to the 2011 Compendium of Physical Activities.[42]

The validity of the PAVS to correctly identify patients as being insufficiently or sufficiently active was assessed using percent agreement between proportions of patients identified by the PAVS and MAQ as not meeting and as meeting aerobic PAG. Concurrent validity and agreement of mins·wk^{-1} MVPA reported to the PAVS with the same reported to the MAQ was assessed by calculating a kappa coefficient of binary agreement between the two PA assessment tools’ proportions of patients meeting and not meeting aerobic PAG and also with Spearman’s rank correlation of the number of mins·wk^{-1} of MVPA reported for each tool, as used by and in order to compare results with primary care PA assessment instruments evaluated by Smith, Marshall, and Huang.[3] Validity of usual mins·wk^{-1} of MVPA reported to the PAVS was assessed using Pearson correlation between mins·wk^{-1} MVPA reported to the PAVS and the same reported to the MAQ. Agreement between mins·wk^{-1} MVPA reported to the PAVS and to the MAQ was assessed using Bland-Altman agreement plots with 95% limits of agreement unadjusted and adjusted for trend.

Correlation and agreement analyses were stratified by patient characteristics. Analyses for the total sample of participants were performed with and without outliers in order to assess the influence of outliers on results. Outliers were identified when mean differences of reported usual mins·wk^{-1} of MVPA exceeded 2.96 standard deviations from the sample's mean difference in MVPA and if any reported PA level exceeded 2.96 standard deviations from the mean reported usual mins·wk^{-1} of MVPA reported on the PAVS and the MAQ, as suggested by Bland and Altman.[43]

Participant-reported confidence levels for reporting PA to the PAVS were dichotomized into "low" and "high" confidence groups according to the median, or 50th percentile, of scores. Differences in the concurrent validity of patient-reported PA to the PAVS between confidence groups was assessed with Spearman's correlation coefficients between each confidence group and usual mins·wk^{-1} MVPA assessed by the MAQ. Spearman correlation coefficients of the low and high confidence groups were tested for statistical difference using a Z-statistic and associated *p*-value.[44]

All analyses were performed with Stata version 11.2 (College Station, TX, USA), and the alpha level used was .05.

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PAVS Version 1 (Avenues Clinic, 2/2012-2/2013; Memorial Clinic, 11/2011-11/2013)	**PAVS Version 2** (Avenues Clinic, 2/2013-present; Memorial Clinic, 11/2013-present)
1. On average, how many days per week do you participate in moderate or greater physical activity (like a brisk walk)? _______ Days/week 2. On those days, how many minutes do you participate at that level? _______ Minutes/day	1. Please describe your level of physical activity: Minutes each day: ______ Number of days each week: ______ 2. At what intensity (how hard): Light (like a casual walk) Moderate (like a brisk walk) Vigorous (like a jog/run)

Figure 1.1. Versions of the self-reported Physical Activity "Vital Sign" used by Intermountain Healthcare, 2011-2014

$$y(binary\ health\ outcome) = \beta_0 + \gamma D(PAVS\ response) + \beta_1(age) + \beta_2(gender) + \mu$$

$\beta_0 = intercept, or\ constant; y(binary\ health\ outcome) = odds\ of\ = \begin{cases} 0: not\ having\ condition \\ 1: having\ condition \end{cases}; PAVS\ response = \begin{cases} 0: meets\ PA\ guidelines \\ 1: does\ not\ meet\ PA\ guidelines \end{cases};$
$\mu = error\ term.$

Figure 1.*2.* Statistical notation of multivariate logistic regression models used to estimate odds of BMI and disease burden categories based on patients' reporting to the PAVS as meeting or not meeting aerobic physical activity guidelines.

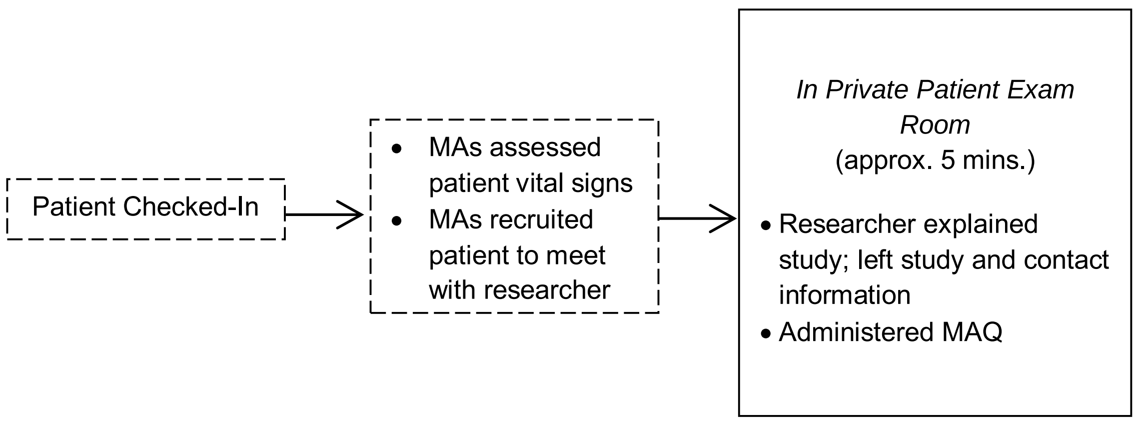

Figure 1.3. Recruitment and study procedures. Dashed boxes signify standard patient care; solid text box signifies study procedures.

CHAPTER 2

VALIDITY OF TWO BRIEF PRIMARY CARE PHYSICAL ACTIVITY QUESTIONNAIRES WITH ACCELEROMETRY IN CLINIC STAFF[2]

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Abstract

To date, no physical activity (PA) questionnaires intended for primary care have been compared against a criterion measure of PA and current (2008) aerobic ACSM/AHA PA recommendations. The purpose of this study was to evaluate preliminary evidence for criterion validity of two brief (<1 min) PA questionnaires with accelerometry and their ability to identify if individuals meet ACSM/AHA PA recommendations. Forty-five health clinic staff wore an accelerometer for 7 consecutive days and afterwards completed two brief PA questionnaires, the Physical Activity Vital Sign (PAVS), and the Speedy Nutrition and Physical Activity Assessment (SNAP). Agreement and descriptive statistics were calculated between the PAVS or SNAP and accelerometry in order to measure each questionnaire's ability to quantify the number of days participants achieved ≥30 mins of moderate to vigorous PA (MVPA) performed in bouts of ≥10 continuous mins. Participants with <5 days of ≥30 bout-mins of MVPA were considered insufficiently active according to PA recommendations.

There was a significant positive correlation between number of days with ≥30 bout-mins MVPA and the PAVS ($r = 0.52$, $p < 0.001$), and SNAP ($r = 0.31$, $p < 0.05$). The PAVS had moderate agreement with accelerometry for identifying if individuals met or did not meet PA recommendations (kappa = 0.46, $p < 0.001$), whereas SNAP had poor agreement (kappa = 0.12, $p < 0.05$).

This study provides preliminary evidence of criterion validity of the PAVS and SNAP with accelerometry and agreement identifying if respondents meet current (2008) ACSM/AHA aerobic PA recommendations. The PAVS and SNAP should be evaluated further for repeatability and in populations varying in PA levels, age, gender, and ethnicity.

Background

Physical inactivity contributes significantly to the leading causes of illness and premature death in the United States, and has consequently become one of public health's greatest concerns (Mokdad et al., 2004, Blair, 2009). Numerous organizations recommend counseling for physical activity (PA) in primary care, including the U.S. Preventive Services Task Force (USPSTF), the American Heart Association (AHA), the American College of Sports Medicine

(ACSM), and the American College of Preventive Medicine (Nawaz and Katz, 2001, Haskell et al., 2007, Lin et al., 2010). Challenges to assessing PA in primary care include having little time to do it while still making the assessment easy to understand. Existing PA assessments intended for use in primary care are too long and too complex and do not reflect current ACSM/AHA aerobic PA recommendations (Glasgow et al., 2005, Smith et al., 2005, Meriwether et al., 2006, Topolski et al., 2006, Fernald et al., 2008).

The accuracy and precision of assessing patient PA becomes increasingly important when clinics adopt a regular practice of assessing PA. In their 2010 review of PA and nutrition behavioral counseling interventions in primary care, the USPSTF found statistically significant, but small, reported changes in PA from relatively common PA interventions that require little time and few resources (Lin et al., 2010). Although greater changes were found when more resources were used, these higher resource PA interventions are not practical for use in primary care. Valid and reliable PA questionnaires are thus especially important when changes in behavior are likely to be relatively small but practically meaningful from a public health perspective. Valid, reliable, and practical primary care measures of PA are also imperative in order to compare the effectiveness of different intervention settings and intensities with populations of varying risk (Glasgow et al., 2005).

To our knowledge, no questionnaires developed to assess PA in primary care have been compared with a criterion measure of PA to correctly classify individuals according to current public health aerobic PA recommendations by ACSM/AHA (Haskell et al., 2007). The Physical Activity Vital Sign (PAVS) and the PA component of the Speedy Nutrition and Physical Activity Assessment (SNAP) were each developed to improve current questionnaires developed to assess PA in primary care. The PAVS was created by a primary care provider and has evidence of construct validity (Greenwood et al., 2010). SNAP was developed with input from culturally diverse focus groups that included providers, staff, and patients from community health clinics. Both the PAVS and SNAP read easily and require less than 1 minute to administer.

The aims of this pilot study were a) to examine the preliminary evidence for criterion and discriminant validity of the PAVS and SNAP with accelerometry in clinic staff and b) to determine how well the PAVS and SNAP correctly classify clinic staff as being sufficiently or insufficiently active according to aerobic ACSM/AHA PA recommendations of acquiring at-least 150 minutes during the past week of moderate-vigorous PA (MVPA).

Methods

Participants

This study was approved by the Institutional Review Board of the University of Utah, and all participants provided written informed consent. Participants were clinic staff recruited from seven primary care clinics in the Salt Lake Valley. Clinic staff were chosen in order to help familiarize clinic staff with these new clinical PA assessments that were being incorporated into regular clinical practice at the time of this study. This study was thus partly a participatory design intended to engage and educate clinic staff that would be responsible for administering these new assessments of PA. Participants were recruited by word of mouth and assistance from clinic administrative staff. Eligible participants included generally healthy men and women ≥18 years of age. Staff with unmanaged chronic disease or musculoskeletal disease that would limit PA or who were pregnant were excluded from this study. For descriptive purposes, basic demographic information was collected by questionnaire.

Instruments

This study assessed only agreement of past week MVPA with the PAVS and SNAP. The PAVS asks two questions designed to assess past and typical week MVPA (Figure 2.1 A) (Greenwood et al., 2010). The PAVS assesses MVPA because of MVPA's association with health outcomes and to facilitate identifying if patients meet aerobic PA recommendations (Haskell et al., 2007). The PAVS has been shown to be feasible to administer at each patient-provider encounter, and most often requires <30 seconds to administer. Consistent with ACSM/AHA PA guidelines, the PAVS specifies that PA be performed in at least one 30-minute, or 3 10-minute bouts.

The PA component of SNAP is distinguished from the PAVS by simultaneously assessing patient cumulative weekly PA, regardless of bouts, as well as readiness to change PA behaviors based on the stages of change construct of the Transtheoretical Model (Figure 2.1 B) (Prochaska and Velicer, 1997). Accordingly, SNAP allows providers to give tailored preventive health counseling and track alterations between stages of behavior change. SNAP has a fifth-grade literacy level, based on the Flesch-Kincaid readability metric, and requires <1 minute to administer (Kincaid, 1975). Basic examples of PA are listed above the single-item questionnaire.

Criterion validity of the PAVS and SNAP was evaluated using data from 7 days of PA monitoring by uniaxial accelerometry (ActiGraph 3GTX, Pensacola, FL). Accelerometry (accel) is the most widely used objective measure of PA and is shown to be a valid measure of free-living PA (Freedson et al., 1998, Hendelman et al., 2000, Matthews, 2005, Rothney et al., 2008, Sasaki et al., 2011). The accelerometers used in this study do not allow wearers to view their activity measured by the accelerometers. Uniaxial (vertical axis) data were used with uniaxial cut-points by Freedson and colleagues in analyzing PA levels (Freedson et al., 1998). These cut-points were chosen in order to compare results to other validated questionnaires that assess PA in primary care, which have most commonly applied uniaxial cut-points by Freedson and colleagues.

Procedures

Data for this study were collected January-September 2010 and evaluated October 2010-June 2011. Participants wore a hip-based accelerometer for 7 days during waking hours and removed the accelerometer during water-based activities. Accelerometers measured motion in the vertical axis and recorded 1-minute intervals of acceleration “counts.” Time spent in water-based activities and when the accelerometer was otherwise not worn was recorded by participants on a daily log sheet. Time spent in these activities was then transformed into accelerometer counts using the activities’ metabolic equivalents identified in the Compendium for Physical Activities (Ainsworth et al., 2011). A student research assistant sent daily text or email messages to participants to remind them to wear the accelerometer. After wearing accelerometers for 7 days, participants self-reported their PA levels on the PAVS and SNAP. Research personnel read the PAVS and SNAP questions to participants in their health clinic office in order to standardize administration of the questionnaires.

Accelerometry data were downloaded using ActiLife software version 5.7.0 (ActiGraph, Pensacola, FL) and evaluated using MeterPlus software, version 4.2 (Santech, Inc., San Diego, CA). Because the PAVS and SNAP intend to measure moderate to vigorous-intensity aerobic activity, minutes per day of accel were calculated at moderate (1952-5724 $ct \cdot min^{-1}$) and vigorous (>5724 $ct \cdot min^{-1}$) levels (Freedson et al., 1998). MVPA was expressed as bout and nonbout data. A PA "bout" was 10 or more continuous minutes of MVPA, wherein a maximum of 2 minutes of activity could be less than moderate intensity. Six hours of accel constituted a valid day, as shown by others (Trost et al., 2005). Seven days of valid accel were required for analysis to avoid transforming missing data that would be less reliable than using real collected data. This allowed us to compare responses of the PAVS and SNAP with PA recommendations as accurately as possible because each questionnaire queried PA performed specifically during the past 7 days.

Participant accel data and responses to the PAVS and SNAP were classified as sufficiently active based on current ACSM/AHA PA recommendations of acquiring ≥30 mins MVPA on at least 5 days of the week. Although the PA recommendations used in this study also recommend an alternative of acquiring 20 mins of vigorous-intensity PA at least 3 days per week, meeting this form of the PA recommendations was not included in this study because preliminary examination of accel data revealed that no participants met this form of the PA recommendations. Subsequently, participant accel data were classified as sufficiently active if ≥30 bout-minutes of MVPA were achieved on ≥5 days of the week (Haskell et al., 2007). Responses to the PAVS question number one were classified as sufficiently active if ≥5 days during the week were reported. Responses to SNAP were classified as sufficiently active if the reported score was 4.

Statistical Analyses

Descriptive statistics were calculated to characterize our sample. Validity of the PAVS and SNAP was assessed distinctively by Pearson (PAVS) and Spearman Rank (SNAP) correlation coefficients between the more continuous nature of the PAVS responses or categorical responses to SNAP and accel. Correlations were specifically determined between the PAVS or SNAP and total weekly minutes of MVPA and with the number of days with ≥30 minutes of MVPA. Discriminant validity between the PAVS and SNAP was assessed by observing differences in each questionnaire's correlations with bout and nonbout MVPA. The abilities of the PAVS and SNAP to identify participants as being sufficiently or insufficiently active were assessed by Kappa coefficients of agreement with accel, positive and negative predictive values, sensitivity, and specificity. Agreement of the PAVS and the number of days with ≥30 bout-mins of MVPA was also assessed by a Bland-Altman agreement plot with 95% limits of agreement. Only the PAVS was assessed by this method because SNAP lacks units of measurement comparable with PA recommendations (ie, number of days with ≥30 bout-mins of MVPA), which is required by a Bland-Altman plot (Bland and Altman, 1986, Bland and Altman, 2010). All data were analyzed using Stata, version 11.1 (College Station, TX, USA).

Results

Eighty-five primary care clinic staff volunteered for this study; two were ineligible due to current pregnancy. Of 83 eligible participants, eight discontinued participation due to lack of time or interest in the study, and 30 were excluded from this analysis because they had <7 days of valid accelerometry (Figure 2.2). There were no significant differences between excluded participants and those with 7 days accel in self-reported days with ≥30 mins MVPA by either the PAVS (<7d accel, Median = 2.0d, IQR = 3.0d; 7d accel, Median = 2.0d, IQR = 2.0d, p = 0.45) or SNAP (<7d accel, Median = 3.0d, IQR = 1.0d; 7d accel, Median = 3.0d, IQR = 1.0d, p = 0.72). Of the remaining 45 participants with sufficient accelerometry data, 42 were female (93%) and 16 were Hispanic (36%). There were also no significant differences between excluded or dropped participants and included participants in age (excluded or dropped, M = 35.0 yrs.; included, M = 38.9, p = 0.14) or in gender (test of proportions, p = 0.36). Participants with complete data were 20-63 years old (M = 38.9 ± 11.8), and their BMI ranged from 19.6 to 47.9 kg/m^2 (M = 30.1 ± 7.9 kg/m^2).

Criterion and discriminant validity

Results of correlation and agreement analyses are provided in Table 2.1. The PAVS was moderately strongly correlated with bout measures of PA and weakly correlated with nonbout measures of PA. In contrast, SNAP was moderately correlated with nonbout PA and weakly correlated with bout-measured PA.

Agreement with meeting PA recommendations

Agreement statistics between the PAVS or SNAP and PA recommendations are provided in Table 2.1 and Figure 2.3. Kappa statistics indicated that the PAVS agreed moderately with identifying if participants met or did not meet PA recommendations (kappa = 0.46, $p < 0.001$), whereas SNAP agreed poorly (kappa = 0.12, $p < 0.05$).

Agreement with accel

Figure 2.4 is a Bland-Altman plot of the average number of days with ≥30 bout-mins of MVPA by accelerometry and the PAVS against the differences of accel and the PAVS. The limits of agreement were constructed around a line of best fit in order to adjust for data that were not normally distributed (Bland and Altman, 1999, Bland, 2006, Ludbrook, 2010). Differences in PA measurement between accel and the PAVS, or bias, were smallest when the average of the PAVS and accel-PA was ≤2 days and ≥4 days. This indicates that the PAVS agrees more strongly with true PA (implied by the average of the PAVS and accel-PA) when true PA is low and high. Although the PAVS appeared in the Bland-Altman agreement plot, by an increasing bias, to increasingly overestimate PA as true PA increased, both the bias and expanding limits of agreement may be due to measurement error from smaller sampling of those with higher PA levels. Overall, 91% of the respondents to the PAVS overestimated being sufficiently active by ≤ 3 days, and 9% overestimated being sufficiently active by 4-7 days.

Discussion

Our findings demonstrate preliminary evidence of criterion and discriminant validity for the PAVS and SNAP, two brief self-report measures of PA intended for use in primary care. We found evidence that the PAVS has a strong ability to identify persons who are insufficiently active that could benefit most from PA counseling and/or interventions, while SNAP did so moderately. Both the PAVS and SNAP correlated significantly with accel-MVPA, although the PAVS correlated more strongly than SNAP.

The PAVS and SNAP demonstrated discriminant validity by their differences in correlation between bout and nonbout minutes of MVPA. The PAVS specifically queries patients about PA in bouts and correlated more strongly with bout-minutes of accel-MVPA than it did with nonbout MVPA. SNAP queries patients about PA not specifically acquired in bouts, and it correlated more strongly with number of days of ≥30 minutes of nonbout MVPA than bout-MVPA. Correspondingly, the PAVS demonstrated good agreement with meeting PA recommendations by accelerometry that currently specify PA be performed in ≥10-minute bouts, whereas SNAP did not.

The PAVS identified strongly those who were insufficiently active, ie, specificity (92% of the time), and SNAP did so moderately (60% of the time). Neither questionnaire had high positive predictive value (correctly identifying participants who were sufficiently active). A PA questionnaire in primary care should predominantly identify patients that most need PA counseling and intervention. Because of the particularly high specificity of the PAVS compared to SNAP, with accelerometry, we are confident that those who self-reported less than 5 days on the first question of the PAVS were in fact not sufficiently active.

To our knowledge, the PAVS and SNAP are the first primary care PA questionnaires evaluated against a criterion measure of PA and ACSM/AHA aerobic PA recommendations updated in 2008 (Haskell et al., 2007). A main difference between the PAVS and other primary care PA questionnaires is that the PAVS does not query PA intensity using the terms “moderate” and “vigorous,” which are reportedly often misunderstood by research participants, and likely by the general population. The PAVS also does not attempt to conceptualize PA into different domains such as transportation, work-related, home/caregiving, and recreational activities wherein activities can be counted more than once and consequently overestimate PA. The high specificity of the PAVS may support a reported assertion that including intensity levels and PA domains in questionnaires may attenuate PA estimates (Altschuler et al., 2009).

Glasgow and colleagues did not consider any current self-report PA questionnaires practical to implement in primary care in their 2005 review of patient self-report measures of health behaviors (Glasgow et al., 2005). Their main finding was that PA questionnaires took too long to complete. Both the PAVS and SNAP were developed to be administered in the least amount of time possible without misclassifying activity levels of patients. The 2 and 3-question PA questionnaires evaluated by Smith et al. (2005) (no names for questionnaires were provided), and the Exercise Vital Sign reported by Coleman et al. (2012) are the shortest PA questionnaires reported to date, requiring a median of 1-2 mins (Smith et al., 2005) and a mean of <1 min (Exercise Vital Sign) to complete. PA questions by Smith et al., however, demonstrated poor agreement with sufficient activity measured by accelerometry (10%) and were evaluated against earlier PA recommendations. To our knowledge, only the Exercise Vital Sign assesses patient PA behaviors as rapidly as the PAVS and SNAP (<1 min).

The decreasing accuracy by which the PAVS measured days with ≥30 bout-mins MVPA as PA increased (see Figure 2.4) may be due to increasing measurement error caused by a small number of participants with 4 or more days with ≥30 bout-mins MVPA. Others have also noted that a small sample with greater than average PA levels is a limitation to assessing agreement between objective and self-report measures of PA (Prochaska et al., 2001, Shephard, 2003). It is also noteworthy that random error, identifiable only by replicate measures of a questionnaire, can inflate limits of agreement (Ludbrook, 2010). Accordingly, Bland-Altman agreement of the PAVS should be interpreted with caution until repeatability of the PAVS is investigated.

Recalling PA by bouts (eg, sets of 10 continuous minutes MVPA) has also previously been reported as a challenge with brief self-report measures of PA (Prochaska et al., 2001). We feel that perhaps placing a greater focus on explaining the nature of "bouts" of PA will improve recall of recommended bout-minutes of MVPA. The PAVS might be improved by prefacing its questions with a more descriptive explanation of "bouts." For example, the PAVS might more accurately measure PA in bouts by first stating "physical activity is most beneficial when performed in 10 or more continuous minutes at a time – how many days in the past week have you performed…"

The findings of this study are not without limitations. The sample of mostly female clinic staff was chosen with a dual purpose of helping clinic staff familiarize themselves with new tools potentially being integrated into clinical practice and to gather preliminary evidence for the validity of those tools. Conclusions therefore cannot be generalized to whole populations. It is noteworthy, however, that the low prevalence of meeting PA recommendations either by MVPA or vigorous PA by accel in this study is similar to other adult populations, including U.S. representative samples (Hagströmer et al., 2007, Troiano et al., 2008, Tucker, 2011). While this may indicate similarity between the PA behaviors of our study sample and the general population, agreement of the PAVS and SNAP with those that meet PA recommendations is unwarranted. A larger and more diverse sample with respect to PA behaviors would help confirm our findings of agreement. Lastly, although the questionnaires were administered in a primary care setting, respondents may interpret the questionnaires differently when administered by a provider.

Our findings demonstrate preliminary evidence of the PAVS to strongly identify insufficiently active people in a sample of clinic staff predominately female. The PAVS appears helpful to identify individuals that most need physical activity counseling from their primary care provider. The ability of SNAP to identify insufficient activity appears moderate, although still comparable to previously evaluated questionnaires that assess PA in primary care (Smith et al., 2005, Meriwether et al., 2006, Topolski et al., 2006). SNAP allows providers to tailor PA counseling because it identifies patients' stage of readiness to change their PA behavior. In order to be congruent with public health aerobic PA recommendations, a primary care PA questionnaire needs to identify MVPA performed in bouts of 10 or more continuous minutes (Haskell et al., 2007). Evidence that determines the usefulness of a primary care PA questionnaire should include statistical agreement with a criterion measure of PA, as well as sensitivity to change, or repeatability (Bland and Altman, 1986, Luiz and Szklo, 2005, Schmidt and Steindorf, 2006, Mâsse, 2010). The PAVS and SNAP should be evaluated further for repeatability and in populations varying in PA levels, age, gender, and ethnicity.

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A)

PAVS

1. How many ***days in the past week*** have you performed physical activity where your heart beats faster and your breathing is harder than normal for 30 minutes or more? (*In 3, 10 minute bouts, or 1, 30 minute bout)*

0 1 2 3 4 5 6 7 (circle one)

2. How many ***days in a typical week*** have you performed activity such as this?

0 1 2 3 4 5 6 7 (circle one)

B)

How Active are You?

Examples of activity are

- Walking
- House work
- Work in the yard or garden
- Dancing
- Jobs that require walking, lifting or other hard work
- Exercise

Are you active for 30 minutes on 5 days of the week?

Circle one number only **Score**

1. No, and I have no plans to be more active.
2. No, but I have been thinking about being more active.
3. Sometimes I am active for 30 minutes, but not all the time.
4. Yes, I am active for 30 minutes on 5 days of the week.

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Figure 2.1. Physical activity questions asked on the (A) Physical Activity Vital Sign (PAVS), and (B), the physical activity component of the Speedy Nutrition and Physical Activity Assessment (SNAP).

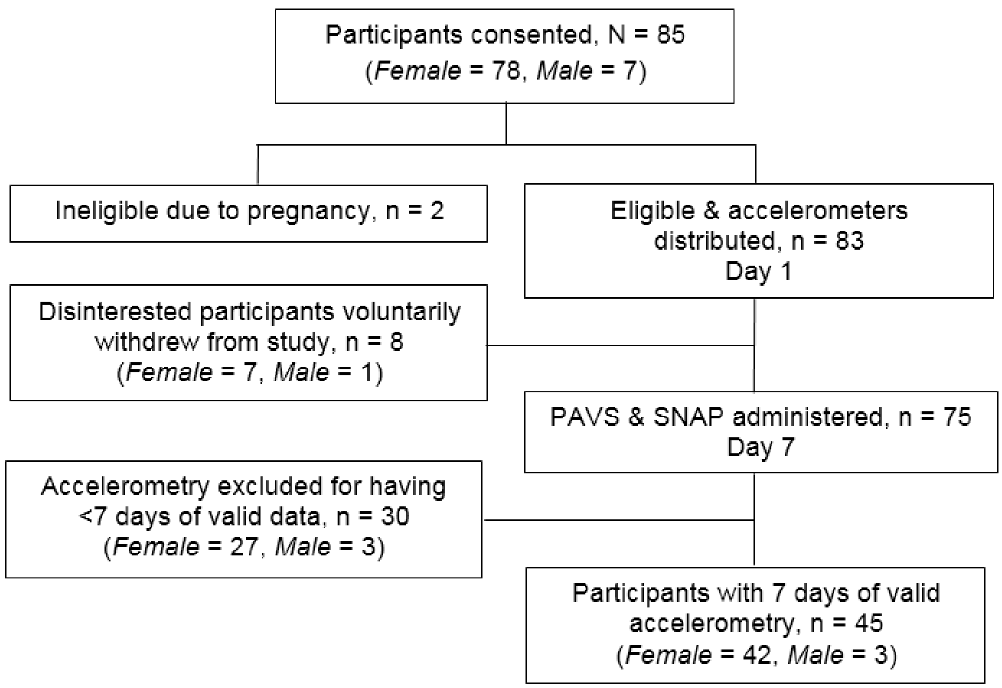

Figure 2.2. Participant enrollment and adherence with questionnaires and accelerometry.

Table 2.1

Criterion and discriminant validity correlation and agreement coefficients comparing the PAVS and SNAP categorical responses with accelerometry.

	Correlation				Agreement
	Total weekly mins MVPA		No. of days ≥30 mins MVPA		
	Bout	Nonbout	Bout	Nonbout	Kappa[c] (95% CI)
PAVS[a]	0.50***	0.33*	0.52***	0.30*	0.46*** (0.04-0.89)
SNAP[b]	0.32*	0.41**	0.31*	0.49***	0.12* (-0.04-0.28)

*** $p < 0.001$
** $p < 0.01$
* $p < 0.05$
[a] Pearson correlation coefficients.
[b] Spearman's rank-order coefficients.
[c] Agreement of the PAVS and SNAP with meeting PA recommendations by accel.
MVPA, moderate to vigorous physical activity; PAVS, Physical Activity Vital Sign; SNAP, Speedy Nutrition and Physical Activity Assessment

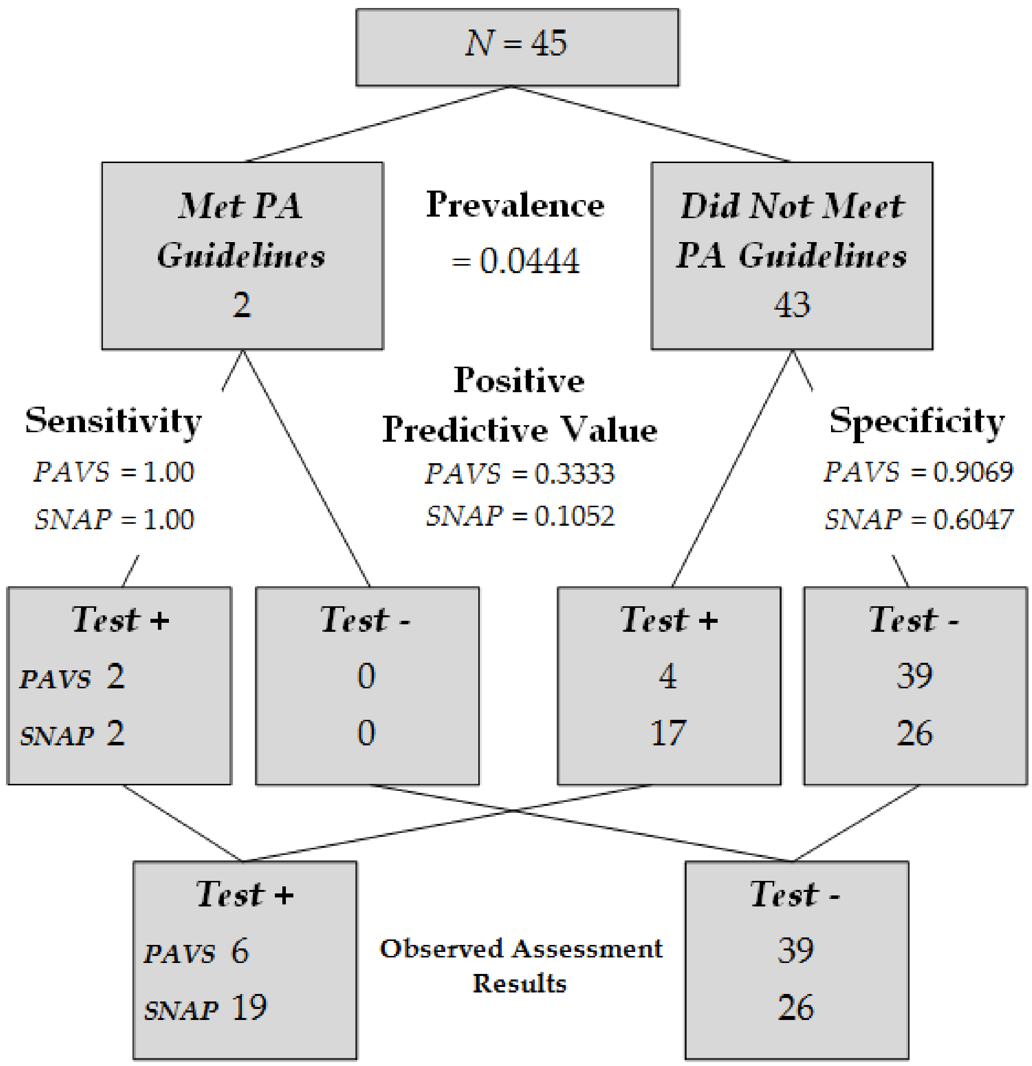

Figure 2.3. Performances of the Physical Activity Vital Sign and Speedy Nutrition and Physical Activity Assessment in identifying participants that meet American College of Sports Medicine/American Heart Association aerobic physical activity recommendations. Proportions of participants who did and did not meet PA recommendations by accelerometry appear at the top, followed by proportions of participants identified by the questionnaires as either meeting (Test +), or not meeting (Test -) PA recommendations. Questionnaire responses are stratified by meeting PA recommendations by accelerometry.

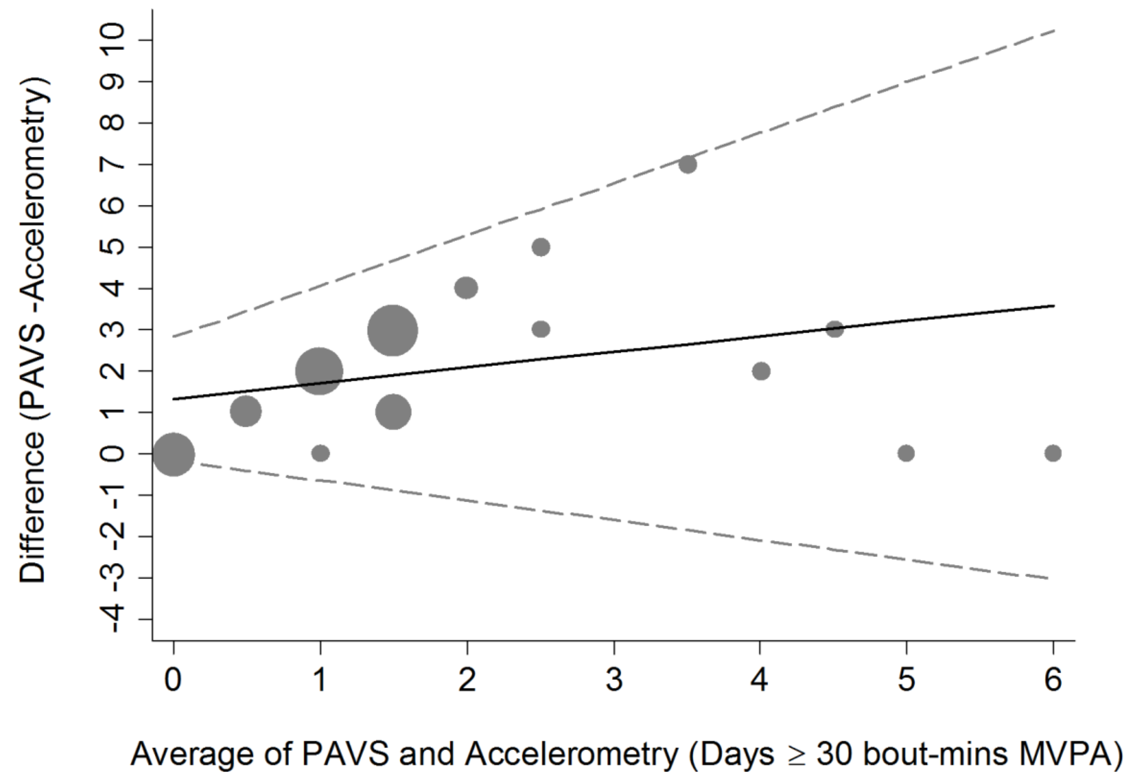

Figure 2.4. Bland-Altman plot assessing agreement between categorical responses to the Physical Activity Vital Sign (PAVS) with uniaxial accelerometry, by units of number of days with ≥30 bout-minutes of moderate-vigorous physical activity. Solid line represents a line of best fit for mean differences between PAVS and accelerometry. 95% limits of agreement about mean differences are superimposed as dashed lines, and circle area is proportional to number of observations.

CHAPTER 3

DEVELOPING CONSTRUCT VALIDITY OF A PHYSICAL ACTIVITY VITAL SIGN FOR ADULTS USING ELECTRONIC HEALTH RECORDS

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Abstract

Health benefits of meeting the *2008 Aerobic Physical Activity* (PA) *Guidelines for Americans* (PAG) are well-known, although it is not known how well responses to the PA vital sign (PAVS) as meeting or not meeting PAG relate to patient health. The purpose of this study was to assess construct validity of the PAVS by assessing odds of being overweight or obese (ie, BMI ≥ 25.0) or having a high Charlson Comorbidity Index according to responses to the PAVS as meeting or not meeting PAG. Body weight status and Charlson Comorbidity Index scores were automatically calculated from data in the EHRs of patients who reported PA levels to a PAVS from November 2011-Novermber 2013. Chi-square analysis was used to test differences in being normal weight verses overweight and scoring below versus above the 50th percentile of the Charlson Comorbidity Index, each according to meeting or not meeting PAG. Odds ratios (OR) from multivariate logistic models were used to determine if patients who reported to the PAVS as not meeting PAG were more likely to be overweight or obese or score higher on the Charlson index compared to patients who reported to the PAVS as meeting PAG.

The number of patient visits eligible for analyses from men and women ≥18 years was 34,712. A majority of participants were female (56.3%), older (≥65 yrs, 43.7%), overweight (BMI 25-29.9, 30.9%) and had a moderate disease burden (Charlson Comorbidity Index 2-4, 32.7%). Patients that did not meet PAG according to the PAVS were more likely than normal weight patients to have a higher BMI (BMI 25.0-29.9, OR = 1.19, $p = 0.001$; BMI 30-34.9, OR = 1.39, $p < 0.0001$; BMI 35.0-39.9, OR = 2.42, $p < 0.0001$; BMI ≥ 40, OR = 3.7, $p < 0.0001$). Patients not meeting PAG were also significantly more likely to have a higher disease burden (above 50th Charlson percentile, OR = 1.8).

The strong association of the PAVS with patient BMI and moderately-strongly with disease burden found in this study supports construct validity of the PAVS. Responses to the PAVS agree strongly with BMI and disease burden that are each known to be influenced by, and influence, PA levels. Future assessments of measurement properties of the PAVS should be done with objective and repeated measures of PA in the patient population.

Background

U.S. adults that meet the *2008 Physical Activity* (PA) *Guidelines for Americans* (PAG) have almost one-half the risk for premature mortality when they have chronic conditions, significantly less cardiovascular and other chronic disease, and improved cancer survivorship compared to their less active counterparts.[1-11] The PAG were established by the U.S. Department of Health and Human Services (DHHS) and recommend that in order to maintain and promote health, adults should accumulate a minimum amount of weekly aerobic PA by at least one of three ways: 1) at least 150 $mins{\cdot}wk^{-1}$ of moderate-intensity PA or 2) 75 $mins{\cdot}wk^{-1}$ of vigorous-intensity PA, or 3) an equivalent combination of 150 $mins{\cdot}wk^{-1}$ of moderate to vigorous intensity PA (MVPA).[12] Because of the health benefits of PA and the broad population reach of medicine, the Exercise is Medicine™ initiative of the American College of Sports Medicine encourages all healthcare providers to assess and review their patient's PA levels at every patient visit.[13] There is currently little evidence that patients who report in clinical settings meeting PAG of the DHHS also have better indices of health compared to patients who do not meet PAG, in spite of the well-known health benefits of PA.[14]

Intermountain Healthcare, Inc., a large healthcare system in Utah and Southern Idaho, began assessing patient PA in 2011 at a few primary care clinics using a very brief (<30 sec), self-report tool called the Physical Activity Vital Sign (PAVS). The PAVS is encouraged to be administered to every patient at every patient visit, in a manner similar to other vital signs such as blood pressure, height, and weight. The PAVS intends to help healthcare providers know which patients most need counseling for physical inactivity and thereby facilitate treating physical inactivity as a leading cause of illness and premature death.[15]

The PAVS previously demonstrated construct validity in a small cross-section of patients by associating strongly with body mass index (BMI, $kg{\cdot}m^{-2}$) and showed preliminary evidence of criterion validity by agreeing with MVPA measured objectively by accelerometry.[16,17] In order to assess the utility of the PAVS as a vital sign that facilitates treating patients, patient responses to the PAVS should be assessed for their association with patient health outcomes, thereby providing evidence of the PAVS' *construct* validity.

The purpose of this study was to assess construct validity of the PAVS by associating patient responses to the PAVS with patient health outcomes recorded concomitantly in electronic health records (EHRs). This study's primary aim was to determine the odds of patients that reported to the PAVS as *not meeting* PAG a) being underweight, overweight, or obese or b) having more comorbidities, indicated by scoring above the 50^{th} percentile of scores for the Charlson Comorbidity Index. We hypothesized that patients who reported to the PAVS as *not meeting* PAG of doing at least 150 $mins \cdot wk^{-1}$ of MVPA would have higher odds of being overweight or obese, as well as scoring above the 50^{th} percentile for the Charlson Comorbidity Index.

Methods

Participants

This study was approved by the Institutional Review Board of Intermountain Healthcare, Inc. Eligible participants for this study were generally healthy men and women 18 years and older who were patients at Intermountain's Memorial Primary Care Clinic between November 1, 2011, and November 1, 2013. Intermountain Healthcare, Inc. is a nonprofit healthcare system of 22 hospitals and approximately 160 healthcare facilities headquartered in Salt Lake City, UT. The cross-section of time for this study was chosen because the PAVS was administered regularly during this time and considered a regular component of these clinics' patient work flows. A 2 year timeframe also allowed accounting for relationships between responses to the PAVS and patient health potentially influenced by seasonal variation in PA and health data recorded in EHRs.

In order to avoid confounding relationships between PA reported to the PAVS and BMI examined as part of this study, patients with clinical conditions known to affect body weight were excluded from this study (ie, their EHRs were excluded). These conditions included ever having bariatric surgery, hyper- or hypothyroidism, being pregnant, having an eating disorder, or being prescribed atypical neuroleptics during the study timeframe. Patient data were also excluded from the analysis of patients who were ever diagnosed with dementia or whose preferred language was not English. These patients were excluded because the PAVS required patients to cognitively recall PA and because the PAVS was administered only in English during the study timeframe.

The Physical Activity "Vital Sign"

Between November 2011-November 2013, the PAVS asked two questions to patients at each patient visit: (1) "On average, how many days per week do you participate in moderate or greater physical activity (like a brisk walk)?" followed by (2) "On those days, how many minutes do you participate at that level?" Similar to other vital signs, the PAVS is embedded in the computer software platform that manages patient EHRs, called HELP2. Medical assistants entered patient responses to the PAVS into HELP2 while checking patients into patient examination rooms. HELP2 estimates $mins \cdot wk^{-1}$ of MVPA reported by the patient by multiplying the number of days per week the patient reported doing PA (PAVS question 1) by the reported average number of minutes doing PA each of those days (PAVS question 2).

The *2008 Physical Activity Guidelines for Americans* include muscle-strengthening PA in addition to the aerobic activity guidelines assessed by the PAVS. However, the PAVS at this time did not assess the muscle-strengthening component of the Guidelines and was therefore not addressed in this study.

Procedures

We examined a retrospective cross-section of all eligible patient EHRs from Intermountain's Memorial Clinic Internal Medicine and Primary Care physicians. Strategies for acquiring data from EHRs were based on best practices currently performed through the Office of Research Clinical Trials at Intermountain Healthcare.

EHR Variables

The primary outcome variables included BMI and Charlson Comorbidity Index scores. BMI was categorized as underweight, <18.5; normal weight, 18.5-24.9; overweight, 25.0-29.9; obese I, 30.0-34.9; obese II 35.0-39.9, and obese III, ≥40. The Charlson Comorbidity Index is an estimate of 10-year mortality risk based upon 17 different health conditions.[18] The Charlson Index is autocalculated from data recorded in the HELP2 EHR. Examples of health conditions that contribute to the Charlson Index include having a myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, or diabetes mellitus. The Charlson Comorbidity Index has a strong degree of direct validity and reliability for patient outcomes related to disease burden, and as such, is used widely to evaluate indirect, or construct, validity of other health data in adult patient EHRs.[19] Patient PA reported to the PAVS should be associated with the Charlson Comorbidity Index because of the known independent associations between physical activity, morbidity, and mortality.[20-22]

Explanatory variables queried included mins·wk^{-1} of MVPA reported to the PAVS, age, and gender.

Analyses

Descriptive statistics were calculated for outcome and explanatory variables of patients who completed and who did not complete the PAVS during their visits between November 2011 and November 2013. To assess construct validity between the PA reported to the PAVS and patient health outcomes from EHRs, differences in meeting and not meeting PAG reported to the PAVS were tested using chi-square tests between patients who were normal weight versus overweight or obese (BMI ≥ 25 kg/m^2) and between patients below and above the 50th percentile of Charlson Comorbidity scores.

Logistic regression was subsequently used to determine odds of being underweight, overweight, obese, or scoring above the 50th percentile of scores from the Charlson Comorbidity Index, according to not meeting PAG. Population average models were used to account for data that were correlated between repeated patient visits.[23] The adequacy and fit of each model was tested using Pearson chi-square and deviance statistics. Fitting models was optimized by adjusting for demographic variables.

All analyses were performed using Stata, version 11.x (StataCorp, LP, College Station TX).

Results

Figure 3.1 illustrates how EHRs were selected and used for final analyses in this study. Table 3.1 describes the characteristics of outpatient visits examined. The number of eligible outpatient visits analyzed was 34,712. Approximately 34% of eligible visits did not have a valid

EHR entry for the PAVS. A majority of patients were female (56.3%), older than 64 years (43.7%), and had an overweight BMI (25-29.9 $kg \cdot m^{-2}$, 30.9%). Most patients reported to the PAVS as not meeting PAG (61.3%). Patients who most often reported to the PAVS not meeting aerobic PAG were female (66.1%), older (≥65 years, 65.9%), had the highest BMI (BMI ≥ 40 $kg \cdot m^2$, 79.2%) and the greatest number of comorbidities, or disease burden (Charlson Comorbidity Index ≥ 5, 74.3%).

Significantly more patients who were overweight or obese (BMI ≥ 25.0 $kg \cdot m^{-2}$) did not meet PAG according to the PAVS compared to patients who were normal weight (BMI 18.5-24.9 $kg \cdot m^2$, $p < 0.0001$). Significantly more patients with the greatest disease burden (ie, above the 50th percentile of scores to the Charlson Comorbidity Index) also did not meet PAG according to the PAVS compared to patients with less disease burden ($p < 0.0001$).

Table 3.2 describes odds of patient BMI classification, compared to normal weight BMI, and having more than the 50th percentile of disease burden (ie, Charlson Index) when not meeting PAG according to the PAVS. No significant differences were found in odds of patients being underweight (BMI < 18.5 $kg \cdot m^2$) compared to normal weight (BMI 18.5-24.9) when not meeting PAG according to the PAVS. Compared to having a normal weight, patients who reported to the PAVS as not meeting PAG were significantly more likely to have a higher BMI. Overall, patients who reported to the PAVS as not meeting PAG were 3.7 times more likely to have a BMI ≥ 40 $kg \cdot m^2$ compared to patients with a normal weight ($p < 0.0001$). The higher patients' BMIs were, the more likely they were to report to the PAVS as not meeting PAG (see Table 3.2).

Patients who reported to the PAVS as not meeting PAG were also significantly more likely to have a higher disease burden according to the Charlson Index. On average, patients who reported to the PAVS not meeting PAG were 1.77 times more likely to score 5 or more for the Charlson Index compared to patients with fewer than 5 points ($p < 0.0001$). Patients with the greatest odds of having a high disease burden when not meeting PAG were female (OR = 1.90, $p < 0.0001$) and those aged 30-39 years (OR = 3.26, $p < 0.0001$).

Discussion

The PAVS is a very brief assessment of patient PA that includes only two questions that require less than 30 seconds to complete. The purpose of the PAVS is to facilitate treating patients for physical inactivity and related illness. These preliminary results provide construct validity of the PAVS by associating patient responses to the PAVS with patient health outcomes recorded in EHRs known to be related to PA. The PAVS was strongly associated with patient BMI and disease burden measured by the Charlson Comorbidity Index (see Table 3.2). These strong associations support the PAVS being used in clinical healthcare as a vital sign that predicts patient health by identifying physical inactivity as an unhealthy behavior.

Similar to other studies, we found that females and older persons were less active than their counterparts (see Table 3.1).[24] Furthermore, the odds of having a higher BMI according to not meeting PAG assessed by the PAVS were higher for older patients compared to younger patients. We feel this was consistent with the construct that younger individuals do not gain weight as reliably as older individuals gain weight when individuals perform little MVPA. Patients with Charlson comorbidity scores beyond the 50th percentile of scores were approximately twice as likely as their counterparts to not have met PAG, with the exception of patients 30-39 years. These middle-aged patients were 3.26 times more likely to not have met PAG compared to patients with a lower disease burden. This finding suggests that disease burden associated with physical inactivity is greatest in middle-aged patients.

Findings from this initial assessment of forms of validity of the PAVS were similar to recent findings of an “Exercise Vital Sign” (EVS) administered regularly to patients in the Kaiser Permanente healthcare system in Southern California.[14] According to the PAVS in this study, 38.7% of patient visits reported being sufficiently active according to the PAG. The EVS indicated that 30.4% of patients to whom the EVS was administered during 1.5 years met the PAG. The same as found by the PAVS, patients who reported to the EVS as being less active had a higher BMI, higher disease burden, and were older. The magnitude of differences, however, between odds of patients that were obese and had a high disease burden were noticeably different between the PAVS and the EVS. For example, patients who did not meet PAG according to the

PAVS were 3.7 times more likely to have a BMI ≥ 40 kg·m^2 compared to normal weight patients, whereas the same identified by the EVS were a much less 1.3 times more likely to have a BMI ≥ 40 kg·m^2. We think a primary reason for the magnitude of these differences is because the EHR data compared with the PAVS included all patient *visits* in a study timeframe where 57% of these patient visits had a Charlson score of ≥2 (see Table 3.1). In contrast, associations between the EVS and EHR data used data from only individual *patients*, wherein only 5.7% of these patients had a Charlson score ≥2.

The primary healthcare setting is an important environment for helping a large proportion of the population attain healthy levels of PA. This is because other behavioral interventions have been successful in the primary care setting, people trust and adhere to health advice by physicians compared to other health professionals, and because many people visit their primary care provider regularly.[25-28] Patients examined in this study visited their primary care or internal medicine doctor at least 2 times per year, and patients over 64 years visited at least 3 times per year. The first steps to helping patients become and remain active at levels equal to or greater than the PAG may begin at the primary healthcare provider's office.

Patients in this study that did not meet PAG according to the PAVS visited their primary care healthcare provider more frequently than patients who met PAG (see Table 3.1). Although this study aimed primarily to examine relationships between patient-reported PA to a PAVS, BMI and disease burden, similar relationships observed thereby were also observed with the number of times patients visit their provider each year. This finding may direct attention towards general healthcare usage and related burden consequent to being less physically active. Relationships between PA and healthcare usage is not known to previously have been examined.

The validity and reliability of assessments of PA in primary care have significant public health implications. Perhaps the most valuable property of measurement in a physical activity vital sign is its ability to correctly identify patients as meeting or not meeting public health PAG. PA assessments used in primary care also need to reliably track changes in patient PA. This reproducibility of a PAVS will allow examining effectiveness of primary care interventions aimed at improving patient PA. The validity and reliability of the PAVS will be important as it is recorded in patient EHRs. Because of the vast health information recorded in EHRs, valid and reliable PAVS can be used to investigate numerous questions concerning physical activity and health. This will enhance public health PAG recommendations and policy alike. Assessing the validity of PA measured by self-report is consequently becoming a public health priority.[29,30]

Healthcare facilities are rapidly adopting patient health records that are electronic. A PAVS recorded within EHRs will facilitate investigating epidemiology of physical activity and other health behaviors that could be assessed in primary care that have presently been accomplished mostly with more costly, independently funded survey and cohort studies. A recent report published by the Robert Wood Johnson Foundation found that the proportion of hospitals that have adopted a system for EHRs has increased 4 times since 2010. This increase is mostly because of federal incentives for adopting a system of EHRs. Almost 60% of hospitals currently have at least a basic system for EHRs.

A strength of this study included assessing validity of a clinical instrument that was administered regularly for at least 2 years. Another strength of this study includes comparison of a self-reported measure of PA with EHRs that are well-population with patient health data. Also, while the PAVS was a measure of PA by self-report, other measures such as BMI, Charlson Comorbidity Index, and patient characteristics are confirmed by well-trained medical staff. Lastly, the timeframe of EHR data analyzed in this study incorporated 2 full years of patient health data and may negate impacts on health from seasonal changes in PA.

Interpreting behavior-disease relationships, such as dose-response relationships, between PA reported to the PAVS in this study and health outcomes in EHRs, could be limited because of the self-report nature of the PAVS. Establishing validity of the PAVS with objective and criterion measures of PA will identify the best relationships to be investigated between the PAVS and health outcomes recorded in EHRs. Future studies investigating measurement properties of the PAVS should also address the PAVS' repeatability by assessing patient PA using the PAVS concurrently with an objective measure of PA, such as accelerometry. Another limitation of this study is the number of potentially eligible visits that were excluded either because a PAVS was not recorded in the EHR or administered (33%) or because BMI was not recorded (14%) (see

Figure 3.1). It's possible that those who entered vital signs into patient EHRs considered not entering responses to the PAVS when patients reported to the PAVS not doing any MVPA. If patient EHRs were missing the PAVS for this reason, it is possible that a substantially greater number of visits from patients who were inactive were excluded from analyses, and results of this study would be attenuated.

Conclusion

The strong association of the PAVS with patient BMI and disease burden found in this study supports assessing patient PA with the PAVS. The PAVS should be assessed further in the clinical setting for agreement with repeated objective measures of PA in order to establish repeatability of the PAVS. With well-established validity and repeatability, the PAVS could be used in conjunction with EHRs to investigate PA-disease relationships as well as clinical interventions aimed to improve patient- and population-level PA. Responses to the PAVS correlate strongly with patient BMI and disease burden. The PAVS therefore appears valuable for assessing PA, a leading health behavior that is associated with health outcomes.

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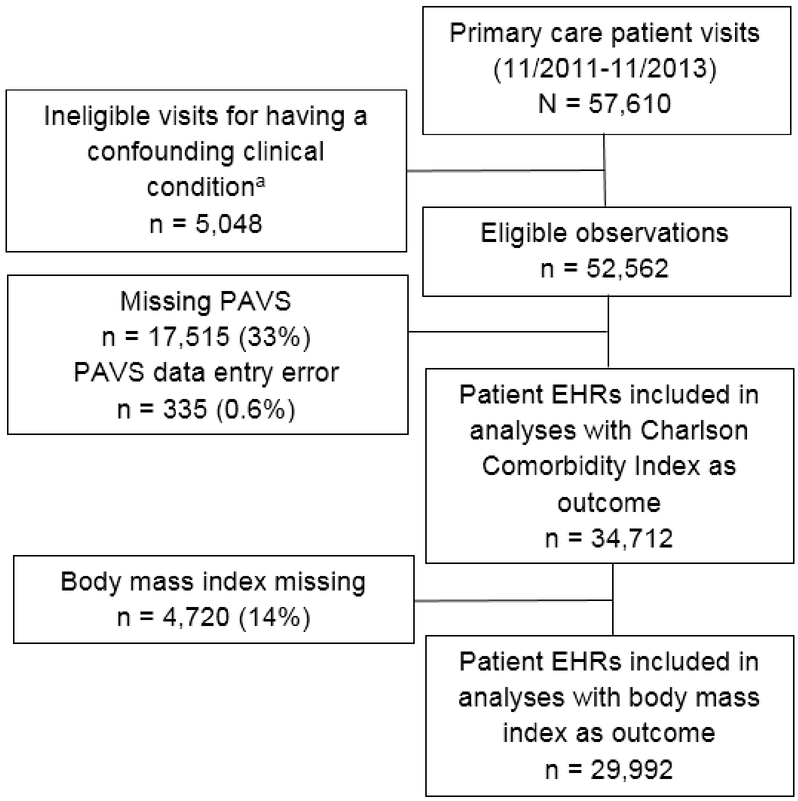

Figure 3.1. How patient electronic health records were included for analyses. [a]Records were excluded for patients with conditions known to confound body mass index, a primary outcome variable in analyses (see Procedures section). PAVS: Physical Activity Vital Sign, EHR: electronic health record

Table 3.1

Characteristics of a clinic's adult primary care and internal medicine outpatient visits during which the Physical Activity Vital Sign was administered and recorded, Nov. 2011-Nov. 2013.

	N (%)	Mean clinic visits per year (SD)	Mean self-reported mins·wk^{-1} MVPA	% Sufficiently Active[a]	% Insufficiently Active
Total	34,712 (100)	2.1 (1.0)	142.6	38.7	61.3
Gender					
Male	15,163 (43.7)	2.0 (1.0)	166.6	45.0	55.0
Female	19,548 (56.3)	2.2 (1.0)	124.1	33.9	66.1
Age					
18-29	2,362 (6.8)	1.2 (0.5)	196.6	54.2	45.8
30-39	3,281 (9.5)	1.5 (0.7)	159.8	44.2	55.8
40-49	3,937 (11.3)	1.7 (0.9)	154.3	43.5	56.5
50-64	9,960 (28.7)	2.1 (0.9)	142.8	38.4	61.6
≥65	15,172 (43.7)	3.1 (1.2)	127.4	34.1	65.9
BMI[b]					
<18.5	409 (1.4)	1.7 (0.9)	143.1	37.9	62.1
18.5-24.9	7,488 (25.0)	1.8 (0.9)	166.5	45.9	54.2
25-29.9	9,268 (30.9)	2.0 (0.9)	157.9	42.9	57.1
30-34.9	6,443 (21.5)	2.3 (1.0)	124.9	34.2	65.8
35-39.9	3,280 (10.9)	2.4 (1.0)	105.7	27.7	72.3
≥40	3,104 (10.4)	2.9 (1.2)	84.3	20.8	79.2
Charlson Index					
0	8,289 (23.9)	1.4 (0.6)	182.1	50.3	49.7
1	6,622 (19.1)	1.8 (0.8)	160.2	43.8	56.3
2-4	11,358 (32.7)	2.6 (1.0)	135.5	37.0	63.0
≥5	8,443 (24.3)	4.0 (1.4)	99.7	25.8	74.3

[a]Determined by meeting *2008 Aerobic Physical Activity Guidelines for Americans* of getting at least 150 mins·wk^{-1} of moderate to vigorous aerobic physical activity.
[b]Nonmissing BMI, N = 29,992; missing BMI, N = 4,720.
SD: standard deviation; MVPA: moderate to vigorous physical activity; BMI: body mass index (kg·m^2)

Table 3.2

Odds of BMI status or having a high disease burden when not meeting *2008 Aerobic Physical Activity Guidelines* assessed by the Physical Activity Vital Sign.[a]

	Underweight (BMI < 18.5)		Overweight (BMI 25.0-29.9)		Obese I (BMI 30.0-34.9)		Obese II (BMI 35.0-39.9)		Obese III (BMI ≥ 40.0)		Charlson Index 50th percentile	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Total	1.30	0.94-1.81	**1.19**	1.07-1.32	**1.39**	1.26-1.53	**2.42**	2.09-2.81	**3.70**	3.04-4.50	**1.77**	1.56-2.00
Gender												
Male	1.04	0.48-2.28	1.08	0.91-1.27	**1.29**	1.11-1.51	**2.42**	1.91-3.08	**4.27**	3.16-5.78	**1.65**	1.38-1.97
Female	1.33	0.91-1.95	**1.28**	1.11-1.47	**1.45**	1.28-1.64	**2.42**	2.00-2.93	**3.42**	2.67-4.40	**1.90**	1.58-2.29
Age												
18-29	1.85	0.95-3.61	1.07	0.78-1.46	1.25	0.94-1.66	1.14	0.69-1.88	**2.95**	1.78-4.89	1.40	0.25-7.72
30-39	0.49	0.21-1.14	1.16	0.87-1.56	**1.32**	1.02-1.70	**2.13**	1.45-3.14	**3.43**	2.29-5.14	**3.26**	1.68-6.34
40-49	2.34	0.96-5.70	**1.55**	1.15-2.10	**1.74**	1.32-2.29	**2.29**	1.54-3.41	**2.59**	1.62-4.14	1.74	0.98-3.09
50-64	1.52	0.78-2.98	**1.33**	1.09-1.63	**1.63**	1.36-1.95	**3.40**	2.64-4.37	**5.16**	3.75-7.11	**1.73**	1.36-2.19
≥65	1.08	0.61-1.91	**1.21**	1.03-1.44	**1.40**	1.20-1.63	**2.80**	2.13-3.67	**4.34**	2.85-6.59	**1.78**	1.53-2.09

Note: Bold indicates statistical significance.
[a]Based on marginal (ie, population average) repeated measure logistic regression models adjusted for age and gender. Individual cells represent a distinct model. Weight status is compared to normal weight (BMI 18.5-24.9). Disease burden assessed by Charlson Comorbidity Index. BMI outcomes, n = 29,992; Charlson Index outcomes, n = 34,712.
BMI: body mass index ($kg \cdot m^{-2}$); OR: odds ratio; CI: confidence interval

CHAPTER 4

CONCURRENT VALIDITY OF A PHYSICAL ACTIVITY VITAL SIGN WITH ADULT PRIMARY CARE PATIENTS

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Abstract

To our knowledge, no patient physical activity (PA) assessment tool administered regularly to patients has been evaluated for validity in identifying if patients do not meet the current (2008) *Aerobic PA Guidelines for Americans* (PAG) established by the U.S. Department of Health and Human Services (DHHS). The purpose of this study was to assess concurrent validity and agreement of a Physical Activity "Vital Sign" (PAVS) with responses to a Modifiable Activity Questionnaire (MAQ). Adult internal medicine patients were administered a MAQ shortly after responding to a regularly administered PAVS. Proportions of the PAVS and the MAQ identifying if patients met DHHS PAG were compared using percent agreements, kappa coefficients of agreement, and Spearman's rank correlation. Usual mins·wk^{-1} of moderate-vigorous PA (MVPA) reported to the PAVS were compared against usual mins·wk^{-1} MVPA reported to the MAQ using Pearson correlation and Bland-Altman plots of agreement.

Two-hundred and sixty-nine patients reported their PA to the PAVS and MAQ. The PAVS agreed with the MAQ 89.6% of the time identifying insufficiently active patients and demonstrated good agreement with the MAQ identifying if patients met PAG (k = .55, rho = 0.57; $p < 0.0001$). Usual mins·wk^{-1} MVPA reported to the PAVS correlated strongly with the same reported to the MAQ ($r = .71$; $p < 0.0001$). Bland-Altman agreement with usual mins·wk^{-1} MVPA between the PAVS and MAQ was fair. The PAVS underestimated PA compared to the MAQ an average of 86.3 usual mins·wk^{-1} MVPA.

The PAVS appears to be a useful and valid tool for identifying patients who most need counseling for PA in the primary care setting because the PAVS correctly identified insufficiently active patients nearly 90% of the time according to the MAQ. The PAVS should be assessed further for agreement with repeated objective measures of PA in the patient population.

Background

Primary healthcare is an environment for promoting population physical activity (PA).[1] Multiple organizations recommend counseling for PA in primary healthcare. These include the U.S. Preventive Services Task Force, the American Heart Association, the American College of Sports Medicine, and the American College of Preventive Medicine.[1-3] The Exercise is Medicine™

initiative of the American College of Sports Medicine is leading a global effort to encourage all healthcare providers to assess and review every patient's PA program at every visit.[4] Doing this requires providers and healthcare systems to have a valid tool for assessing patient PA within the workflow of a typical visit.

Tools for assessing patient PA are being developed and administered regularly to primary healthcare patients.[5-12] Different tools for assessing patient PA are appropriate for different purposes. Strath and colleagues offer guidance for selecting an appropriate patient PA assessment tool in a statement from the American Heart Association.[12] At a minimum, a PA assessment tool for patients should be able to assess if a patient meets public health PA guidelines such as the *2008 Aerobic PA Guidelines for Americans* (PAG) of the DHHS.[11] The DHHS recommends that to promote and maintain health, adults should accumulate at least 150 $mins{\cdot}wk^{-1}$ of moderate PA, or 75 $mins{\cdot}wk^{-1}$ of vigorous PA, or an equivalent combination of 150 $mins{\cdot}wk^{-1}$ of moderate-vigorous PA (MVPA).[13]

To our knowledge, no PA patient assessment tools have been evaluated for validity and agreement in identifying if patients meet PAG. Responses to the Physical Activity "Vital Sign" (PAVS) were recently compared against objective measures of PA by accelerometry and 2007 aerobic PA guidelines of the American College of Sports Medicine and the American Heart Association.[2,6] Since that study, the PAVS has been modified to assess if a patient meets PAG of the DHHS. Whereas the ACSM and AHA recommend adults perform MVPA for at least 30 minutes/day for at least 5 days/week, the DHHS recommends adults perform an accumulative number of $mins{\cdot}wk^{-1}$ MVPA describe earlier, although they encourage PA be done most days of the week. The PAVS has also since become a regular part of clinical practice and is recommended to be administered to every patient at every patient visit in select Intermountain Healthcare clinics in Northern Utah.

The primary aim of this study was to assess validity and agreement of the PAVS with responses to a concurrently administered Modifiable Activity Questionnaire (MAQ). A secondary aim of this study included examining if there were differences in concurrent validity between patients' level of confidence reporting PA to the PAVS.

Methods

Participants

Participants in this study were volunteer, adult (≥18 years) primary care and internal medicine patients at two clinics of Intermountain Healthcare, Inc. in Northern Utah. Patients were not eligible to participate if they did not speak English or if they had diagnosed dementia because the PAVS was administered only in English at the time of this study and because the PAVS required cognitively recalling PA behaviors. Intermountain Healthcare is a nonprofit healthcare system that consists of 22 hospitals and approximately 160 healthcare facilities located throughout Utah and Southern Idaho. The Intermountain Healthcare Institutional Review Board approved this study. We calculated that a sample of 268 participants completing both the PAVS and the MAQ would provide 95% confidence intervals around a Cohen's kappa for agreement of 46% (estimated from previous study)[6] between proportions of patients identified as meeting or not meeting PAG assessed by the PAVS and MAQ.[14]

Physical Activity Vital Sign (PAVS)

The PAVS is a very brief PA questionnaire (<30 seconds) administered to every patient at every clinic visit in a manner similar to other vital signs such as blood pressure, temperature, height, and weight. The PAVS is intended to assess how much light, moderate, or vigorous intensity PA a patient performs in a typical week. This facilitates identifying if a patient meets PAG and facilitates counseling about PA with patients.[13]

This brief, self-reported vital sign asks patients two questions, typically directly after a patient checks in for their appointment: (1) "Please describe your level of physical activity, [first by] minutes per day, [followed by] number of days each week" and (2) "at what intensity (how hard): *light* (like a casual walk), *moderate* (like a brisk walk), or *vigorous* (like a jog/run)?" Responses are recorded by medical assistants or the patient's physician in the electronic health record. Total mins·wk^{-1} of PA that were reported by the patient as "light," "moderate," or "vigorous" are automatically calculated by the electronic health record by multiplying average minutes/day of PA by average days/week of PA. MVPA is automatically calculated by summing mins·wk^{-1} of "moderate" and "vigorous" PA.

Modifiable Activity Questionnaire (MAQ)

The MAQ is “modifiable” because it only queries activities identified as commonly performed by the population of a study. A systematic approach was used to choose the MAQ for evaluating concurrent validity with the PAVS, following steps recently developed by Sternfeld and Goldman-Rosas.[15] The most notable reason for selecting the MAQ to assess concurrent validity with the PAVS was that the MAQ had the strongest established validity among PA assessment instruments that measure mins·wk^{-1} of MVPA, which are the traits of the PAVS that facilitate assessing if a patient meets PAG.[16-18] Although previous studies have found the MAQ to associate strongly with PA measured objectively by accelerometry, the number of questions included with the MAQ make the MAQ too long and unfeasible for use in a primary care clinic setting noted also by others.[6-8]

The MAQ used in this study included moderate to vigorous activities most commonly performed according to Utah PA responses to the 2012 Behavioral Risk Factor Surveillance System (BRFSS).[19] In order to facilitate recalling PA, the MAQ in this study queried past week PA and asked respondents if their responses reflected “usual” PA (see appendix for the MAQ used in this study).

Procedures

Physicians at two primary care and internal medicine clinics of Intermountain Healthcare allowed access to their patients for this study. Patients were recruited by medical assistants after assessing patients’ vital signs in private exam rooms. In order to help control bias of volunteer participation by patients, the invitation to recruit patients was recited by medical assistants from an index card. Medical assistants specifically did not mention “physical activity” while recruiting patients in order to facilitate attaining a sample of participants that would represent PA trends of their adult clinic population. After patients provided verbal consent to medical assistants to learn more about the study, greater details of the study and the MAQ were described by student research assistants in a private room.

Research assistants first asked patients how confident they felt reporting their PA to the PAVS administered to them earlier during their appointment and afterwards administered the

MAQ. Confidence was reported on a scale of 1-5, where 1 = very unsure, 2 = quite unsure, 3 = about 50/50, 4 = quite sure, and 5 = very sure. The MAQ was completed an average of 30 minutes after patients reported their PA to the PAVS. It was not feasible to randomize the order of PAVS and MAQ assessments due to lack of privacy in clinic waiting areas and our desire to not interfere with typical patient flow through the clinic.

Analyses

To help assess how well the volunteer participants in this study represented the total eligible population within participating clinics, proportions of gender and age groups between volunteer participants and eligible participants were compared using two-sample tests of proportions. Other descriptive data of eligible participants were not available for analysis.

Correlation and agreement were tested between $mins \cdot wk^{-1}$ MVPA reported to the PAVS and $mins \cdot wk^{-1}$ MVPA reported to the MAQ. Correlation and agreement between the two PA assessment instruments were tested only for patients who indicated that PA reported to the MAQ was “usual” for them because the PAVS assesses usual activity. Participants who indicated that PA reported to the MAQ was not “usual” for them were excluded from all analyses. Because PAG can be met by accumulating an “equivalent [weekly] combination” of MVPA, minutes performing activities included in the MAQ that were of vigorous intensity, compared to moderate, were weighted twice when summing total usual $mins \cdot wk^{-1}$ MVPA for participants (see DHHS, 2008). Activities included in the MAQ were identified as vigorous or moderate according to the 2011 Compendium of Physical Activities.[20]

Concurrent validity and agreement of $mins \cdot wk^{-1}$ MVPA reported to the PAVS with the same reported to the MAQ was assessed by calculating a kappa coefficient of binary agreement between the two PA assessment tools’ proportions of patients meeting and not meeting PAG and also with Spearman rank correlation of the number of $mins \cdot wk^{-1}$ of MVPA reported for each tool. Validity of usual $mins \cdot wk^{-1}$ of MVPA reported to the PAVS was assessed using Pearson correlation between $mins \cdot wk^{-1}$ MVPA reported to the PAVS and the same reported to the MAQ. Agreement between $mins \cdot wk^{-1}$ MVPA reported to the PAVS and to the MAQ was assessed using Bland-Altman agreement plots with 95% limits of agreement, unadjusted and adjusted for trend.

Correlation and agreement analyses were stratified by patient characteristics. Analyses for the total sample of participants were performed with and without outliers in order to assess the influence of outliers on results. Outliers were identified when mean differences of reported usual mins·wk^{-1} of MVPA exceeded 2.96 standard deviations from the sample's mean difference in MVPA, as recommended by Bland and Altman.[21] and if any reported PA level exceeded 2.96 standard deviations from the group mean reported usual mins·wk^{-1} of MVPA reported on the PAVS and the MAQ.

Participant-reported confidence levels for reporting PA to the PAVS were dichotomized into "low" and "high" confidence groups according to being either below or above the 50th percentile of scores. Differences in the concurrent validity of patient-reported PA to the PAVS between confidence groups was assessed with Pearson correlation coefficients between each confidence group and usual mins·wk^{-1} MVPA assessed by the MAQ. Pearson correlation coefficients of the low and high confidence groups were tested for statistical difference using a Z-statistic and associated *p*-value.[22]

All analyses were performed with Stata version 11.2 (StataCorp LP, College Station TX, USA), and the alpha level used was .05.

Results

Participant Characteristics and PA Behaviors

Three-hundred and five patients consented to participate in this study (Figure 4.1). Demographic characteristics of participants were recorded for 298 participants (Table 4.1). There were no statistical differences in proportions of gender and age groups between participants and eligible participants. A majority of participants were female (61.4%) and Caucasian (88.9%). Two-hundred sixty-nine participants indicated that PA reported to the MAQ was "usual" for them and were compared with PA reported to the PAVS. Patients who reported the greatest usual mins·wk^{-1} of MVPA by both the PAVS and the MAQ were younger and more educated than patients who reported less PA (Table 4.2).

Validity and Agreement Statistics

Table 4.3 includes agreement and correlation coefficients between the PAVS and the concurrently administered MAQ stratified by patient characteristics. The PAVS agreed strongly with the MAQ identifying patients who were insufficiently active, doing so 89.6% of the time. The PAVS demonstrated good agreement for correctly identifying patients as meeting or not meeting the PAG when accounting for agreement occurring by chance (k = 0.55, $p < 0.0001$). The PAVS correlated strongly with the MAQ for assessing patient usual mins·wk^{-1} of MVPA ($r = 0.71$, $p < 0.0001$) and moderately-strongly with the MAQ by categorically identifying patients as meeting or not meeting PAG ($r = 0.57$, $p < 0.0001$). Eight of 269 participants met predetermined criteria as outliers. Correlation and agreement coefficients from analyses that excluded data from outliers were not noticeably different than analyses that included outliers (see Table 4.3).

Patients who most frequently were correctly identified as being insufficiently active included females (90.1%) and patients with education <university (90.9%). Agreement for identifying patients as meeting or not meeting PAG was strongest for patients with high confidence reporting PA to the PAVS (79.9% of the time; k = 0.60, $p < 0.0001$) and with older patients (80.0% of the time; k = 0.60, $p < 0.0001$). Usual mins·wk^{-1} MVPA reported to the PAVS correlated most strongly with the same reported to the MAQ among patients who had high confidence reporting PA to the PAVS ($r = 0.74$, $p < 0.0001$), males ($r = 0.81$, $p < 0.0001$), and with patients who were younger ($r = 0.75$, $p < 0.0001$) (see Table 4.3).

Bland-Altman Agreement

Bland-Altman agreement plots between usual mins·wk^{-1} MVPA assessed by the PAVS and the MAQ are presented as Figures 4.2 A-I. Data from outliers were excluded from agreement plots (n = 8) in order to facilitate visually interpreting agreement plots. Bland-Altman agreement between the PAVS and the MAQ was fair. For total participants, 95% confidence limits were wide (-371.3-198.7 mins·wk^{-1}), and participants reported an average of 86.3 fewer usual mins·wk^{-1} of MVPA to the PAVS (128.5) compared to the MAQ (214.8; $p < .001$) (Figure 4.2 A). Based on limits of agreement (ie, confidence bounds), agreement between usual mins·wk^{-1} reported to the PAVS and the same reported to the MAQ was greatest for patients who had high confidence reporting PA to the PAVS (Figure 4.2 C), who were female (Figure 4.2 E), and who completed university-level education (Figure 4.2 I). Figure 4.2, column 3, illustrates that the PAVS agreed best with usual mins·wk^{-1} of MVPA measured by the MAQ in patients who had lower activity levels and increasingly disagreed with, mostly underestimating, mins·wk^{-1} of MVPA measured by the MAQ in more active patients.

Participant Confidence Reporting PA and Common Activities

A majority of patients felt "very sure" that their PA reported to the PAVS was accurate (68%). Usual mins·wk^{-1} of MVPA assessed by the PAVS were more strongly correlated with usual mins·wk^{-1} of MVPA assessed by the MAQ among the participants with high confidence self-reporting their PA (r = 0.74) compared to participants with low confidence self-reporting PA (r = 0.63, p = .01). Table 4.4 describes the prevalence of moderate-vigorous activities most commonly reported to the MAQ by participant gender and age groups. The most common activities reported by all participants were walking (66.6%), lifting weights (24.6%), and calisthenics (20.0%) (eg, sit-ups, pushups, etc.).

Discussion

The PAVS appears to have a strong ability to identify patients who are insufficiently active according to PAG, thus identifying patients who most need counseling for being physically inactive. This was demonstrated by the PAVS identifying insufficiently active patients the same as the MAQ 89.6% of the time. An advantage of the PAVS over other tools is that it takes less than 30 seconds to administer.

To our knowledge, this is the first study to evaluate the ability of a patient PA assessment tool to correctly identify if patients meet PAG. This is also the first study we are aware of to assess concurrent validity of a brief patient PA assessment tool measuring mins·wk^{-1} of MVPA with a research-based PA assessment tool that has established validity for measuring mins·wk^{-1} of MVPA. Counseling patients for physical inactivity in the healthcare setting is perhaps best facilitated by identifying if patients meet public health PA guidelines. This is because our public health PAG are based on preventing disease and promoting health.[13] The first step in treating patients for physical inactivity within the healthcare setting is *assessing* their PA with an instrument that has evidence for being valid, can be feasibly administered in the clinical setting, and is understood by patients.

According to the results of the Bland-Altman plots of agreement between PA reported to the PAVS and to the MAQ, dose-response estimates between PA reported to the PAVS and other clinical health outcomes would appear to be attenuated. This is because the PAVS underestimated usual mins·wk^{-1} of MVPA an average of 86.3 mins·wk^{-1} compared to the MAQ. It is noteworthy; however, although the MAQ is strongly correlated with an objective measure of PA by accelerometry, the MAQ may overestimate PA because the MAQ provides more opportunity to report PA compared to the PAVS (ie, the MAQ lists more domains, or types, of PA). Researchers previously found through cognitive interviews that examined self-reporting behaviors of PA that PA can be over-reported when PA is contextualized by domains, such as was done by the MAQ used in this study.[23] This finding might be confirmed by this study's finding that more PA was reported to the MAQ in all demographic groups of participants compared to PA reported to the PAVS.

The validity of clinical assessments of PA has profound implications for population health. Clinical assessments of PA that are valid facilitate treating only those patients who most need counseling for physical inactivity, similar to other clinical assessment tools that intend to identify patient needs. Valid clinical assessment of PA will also minimize measurement error for epidemiologic investigations of PA and health outcomes that use this clinical assessment of PA as PA is increasingly recorded in electronic health records.[5,24]

Usual mins·wk^{-1} MVPA assessed by the PAVS, compared to the MAQ in this study, was underestimated. This demonstrates either a need for the PAVS to capture more PA performed by patients, or that the MAQ overestimated PA, or both. If the PAVS underestimates true PA of patients, the PAVS could capture more patient PA perhaps by adding additional instructions to its assessment. For example, the PAVS could include an introductory explanation for patients to think of *all* PA performed and not just PA done purposefully as "exercise." The PAVS might also capture more patient PA by accommodating reporting PA performed at more than one level of intensity. At the time of this study, the PAVS allowed patients to report only one level of PA intensity as either "light," "moderate," or "vigorous." In this way, patients may either have omitted reporting some activity or adapted their perceived PA intensity to accommodate one of the three intensities currently available to report to the PAVS. For example, some vigorous intensity PA might be adapted as moderate PA. This would underestimate a patient's $mins \cdot wk^{-1}$ MVPA because it would underestimate the greater numerical value of vigorous intensity minutes of PA (see DHHS, 2008).

It is important for patient-reported PA to agree with objective measures of PA with established validity in order to accurately estimate subsequent behavior-disease relationships between patient-reported PA and health-related outcomes recorded in electronic health records. Although agreement between usual $mins \cdot wk^{-1}$ MVPA reported to the PAVS and the same reported to the MAQ in this study was only fair and had wide limits of agreement, this is common with assessments of PA that are self-reported.[25,26] Notably, the very brief PAVS agreed better with usual $mins \cdot wk^{-1}$ of MVPA assessed concurrently with a MAQ compared to agreement between a lengthier past week assessment of minutes of MVPA assessed by, for example, the International Physical Activity Questionnaire and a log book that assessed MVPA in ways similar to the MAQ used in this study.[26] Our interpretation of agreement plots in Figures 4.2 A-I that include limits of agreement by trend (column 3) is limited by our study population, which had few individuals with high reported levels of PA; assessing the validity of the PAVS more reliably with very active patients would require a greater sample of active patient-participants and is an area for further research.

PA reported by patients in this study agreed and was correlated most strongly with patients who indicated feeling most confident reporting their PA to the PAVS. Others have also observed this relationship.[27] The accuracy of epidemiologic studies that use PA reported by patients and identifiable health outcomes in medical records may be improved by understanding factors such as confidence in self-reporting PA. Patient confidence in reporting PA might improve as patients report their PA more frequently to a PAVS and as a PAVS is administered in clinics more regularly. This could be investigated with other studies and may help further assess measurement properties of a PAVS.

Counseling PA with inactive patients might be facilitated by querying domains of PA (ie, types of PA) as part of a PAVS, in addition to levels of PA. Physicians could use this information to suggest to patients activities that are commonly performed by other patients of their same demographic. The Centers for Disease Control and Prevention similarly began querying PA domains to facilitate promoting PA starting with their 2011 BRFSS survey of population PA behaviors. Clinics and providers could use small area BRFSS PA reports that in the future might include results of common PA domains performed by the population served by their clinic. Or clinics and providers could consider querying PA domains as part of a PAVS, in addition to querying levels of PA.

Strengths of this study include assessing measurement properties of the PAVS only in clinics that regularly used this instrument as part of routine patient workflow. The PAVS was recommended to assess PA in adult patients by administering the PAVS to every patient at every visit for approximately 2 years before this study assessed concurrent validity of the PAVS with the MAQ. The PA questionnaire chosen to assess concurrent validity of the PAVS in this study, the MAQ, demonstrated the best objective measures of validity among known PA questionnaires that measure the same constructs as the PAVS.[18]

The self-report nature of the MAQ used in this study limits interpretation. Also, as mentioned previously, the MAQ appears to overestimate PA more than the PAVS was known from earlier studies to overestimate PA.[6] The MAQ was chosen to be compared against the PAVS because the MAQ was most strongly correlated with objective measures of PA by accelerometry in a recent review of PA questionnaires.[18] However, a better instrument used to assess concurrent validity of any PA self-report assessment might be an instrument not with criterion validity assessed by correlation but instead by agreement. Similar to validation studies of the MAQ with criterion measures of PA, this study found a strong relationship between the PAVS and an MAQ by correlation, but not by Bland and Altman agreement, for example. We feel that a better concurrent assessment of the validity of PA assessed by the PAVS would be done with another PA questionnaire with well-established validity by *agreement* with a criterion measure of PA. The measurement properties of any PA self-report assessment tool, including a PAVS, is assessed most robustly by objective measures of PA, such as by multisensory monitors or accelerometry. Other limitations to this study include participants being mostly Caucasian. The PAVS was also assessed for concurrent validity in this study only with patients that spoke English. The findings of concurrent validity of the PAVS in this study are only representative of the patient population that participated. Lastly, the PAVS assessed in this study assessed patient PA done only at one level of intensity that was either “light,” “moderate,” or “vigorous,” but not activity done at each of these intensities. In order for this assessment of patient PA to be used with, for example, patient EHRs to examine PA-disease relationships, we think the PAVS should assess patient PA done at each of these three intensities, “light,” “moderate,” and “vigorous.”

Conclusion

This study found strong evidence for the ability of the self-reported Physical Activity “Vital Sign” to correctly identify patients who are insufficiently active according to PAG, compared to concurrent responses to a MAQ. On average, the PAVS underestimated patient usual mins·wk^{-1} of MVPA compared to usual mins·wk^{-1} of MVPA assessed by a MAQ. The PAVS should be assessed further for its ability to reliably track trends in patient PA, as well as the validity of using electronic records of patient PA for epidemiologic investigations. These assessments would best be done with measures of PA that are repeated, objective, and assessed in the patient population.

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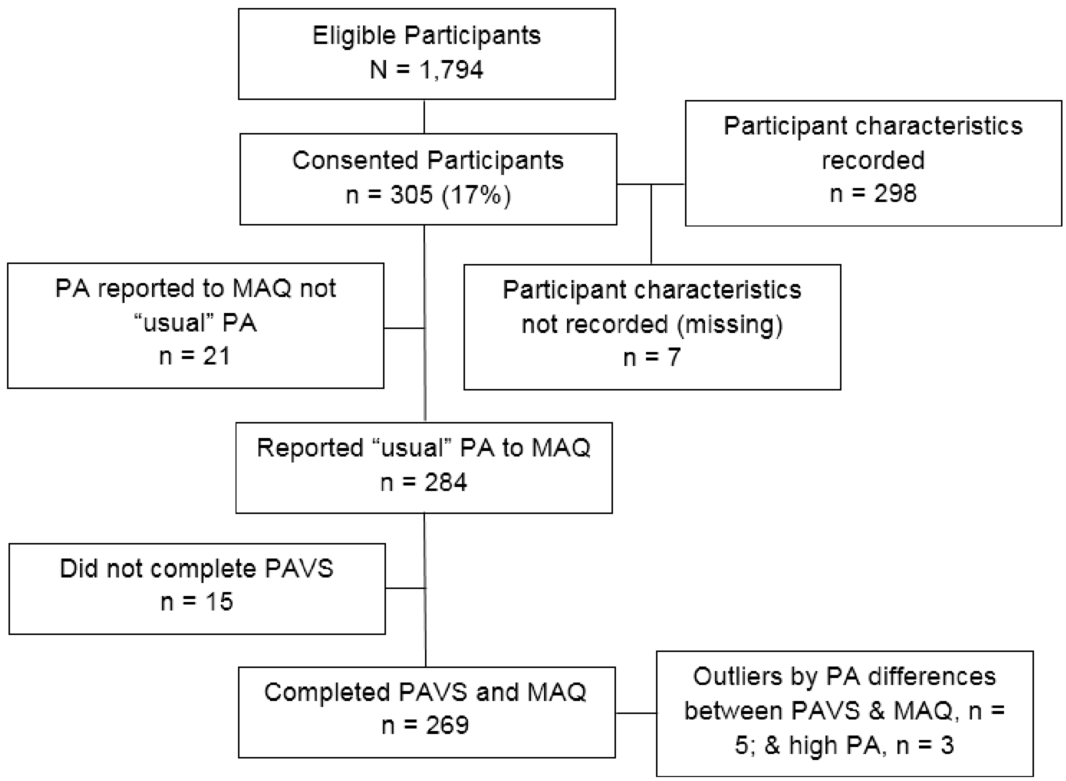


Figure 4.1. Recruitment and other procedures that determined participants included for analyses. PA: physical activity; MAQ: modifiable activity questionnaire; PAVS: physical activity “vital sign.”

Table 4.1

Characteristics of participants and eligible participants compared by proportions of gender and age groups.

	Total (%)		Male (%)			Female (%)		
	Participants	Eligible Participants	Participants	Eligible Participants	*p*	Participants	Eligible Participants	*p*
Total	298 (100.0)	7600 (100.0)	115 (38.6)	3,208 (42.2)	0.44	183 (61.4)	4,392 (57.8)	0.33
Age (years)								
18-34	33 (11.1)	768 (10.1)	16 (13.9)	292 (9.1)	0.52	17 (9.3)	476 (10.8)	0.84
35-54	63 (21.1)	1,656 (21.8)	26 (22.6)	754 (23.5)	0.92	37 (20.2)	902 (20.5)	0.96
≥55	202 (67.8)	5,176 (68.1)	73 (63.5)	2,162 (67.4)	0.48	129 (70.5)	3,014 (68.2)	0.58
Educational Level								
Some high school	9 (3.0)	-	4 (3.5)	-	-	5 (2.7)	-	-
High school	59 (19.9)	-	17 (14.9)	-	-	42 (23.0)	-	-
Tech college/other	75 (25.3)	-	28 (24.6)	-	-	47 (25.7)	-	-
University	154 (51.9)	-	65 (57.0)	-	-	89 (48.6)	-	-
Ethnicity								
Latino/Hispanic	2 (0.7)	-	2 (1.8)	-	-	0 (0.0)	-	-
Asian/Pacific Islander	11 (3.7)	-	5 (4.4)	-	-	6 (3.3)	-	-
Native American	16 (5.4)	-	7 (6.2)	-	-	9 (4.9)	-	-
Caucasian	263 (88.9)	-	97 (85.8)	-	-	166 (90.7)	-	-
African American	1 (0.3)	-	0 (0.0)	-	-	1 (0.6)	-	-
No response	3 (1.0)	-	2 (1.8)	-	-	1 (0.6)	-	-

Note: *p*-values are for two-sample tests of proportions between characteristics recorded for participants and characteristics of eligible participants. Characteristics of eligible participants were acquired from electronic health records. Empty cells signify characteristics of eligible participants that were not available for analysis.

Table 4.2

Patient physical activity levels reported by assessment instrument and patient characteristics (N = 269).[a]

	Mean usual mins·wk^{-1} MVPA			% Insufficiently active			% Sufficiently active		
Characteristic	PAVS	MAQ	Difference	PAVS	MAQ	Difference	PAVS	MAQ	Difference
Total	150.4	240.8	-90.4	56.9	42.8	14.1	43.1	57.3	-14.2
Outliers excluded (n = 8)	128.5	214.8	-86.3	57.9	43.7	14.2	42.2	56.3	-14.1
Confidence reporting PA[b]									
Low	106.2	209.1	-102.9	70.9	50.6	20.3	29.1	49.4	-20.3
High	170.5	254.2	-83.7	52	39.7	12.3	48	60.3	-12.3
Gender									
Male	214.4	294.7	-80.3	48.0	33.0	15	52.0	67.0	-15
Female	108.2	203.9	-95.7	63.2	49.7	13.5	36.8	50.3	-13.5
Age (years)									
18-34	216.4	433.9	-217.5	35.7	21.4	14.3	64.3	78.6	-14.3
35-54	173.9	239.9	-66	50.0	42.9	7.1	50.0	57.1	-7.1
≥55	134.0	211.2	-77.2	62.0	46.2	15.8	38.0	53.8	-15.8
Educational Level									
Some high school	70.0	238.3	-168.3	77.8	55.6	22.2	22.2	44.4	-22.2
High school	130.0	214.0	-84	62.8	56.9	5.9	37.3	43.1	-5.8
Tech college/other	147.9	228.2	-80.3	65.2	46.4	18.8	34.8	53.6	-18.8
University	154.5	240.5	-86	50.0	35.5	14.5	50.0	64.5	-14.5

MVPA: moderate-vigorous physical activity; PAVS: physical activity "vital sign"; MAQ: modifiable activity questionnaire; PA: physical activity

[a]Except where indicated, table does not include data from outliers (n = 8).

[b]Patient-reported confidence reporting physical activity to the physical activity "vital sign"; dichotomized by 50th percentile of confidence scores on Likert scale of 1-5 where 5 was most confident. Low = 1-4; High = 5.

Table 4.3

Agreement and correlation coefficients between the Physical Activity "Vital Sign" and a Modifiable Activity Questionnaire in adult patients of primary care by patient characteristic.

	N[a]	% agree for insufficient activity	% agree for sufficient activity	Total % agree	Kappa (95% CI)	Pearson's r: mins·wk^{-1} MVPA	Spearman's rho: identifying meeting PA guidelines
Total	269	89.6	67.5	77.0	0.55 (0.45-0.64)*	0.71*	0.57*
Outliers excluded[b]	261	90.4	67.4	77.4	0.56 (0.46-0.65)*	0.66*	0.58*
Confidence reporting PA[c]							
Low	90	88.6	54.3	72.2	0.44 (0.25-0.60)*	0.63*	0.48*
High	179	84.6	72.3	79.9	0.60 (0.49-0.71)*	0.74*	0.62*
Gender							
Male	100	87.9	71.6	77.0	0.53 (0.38-0.69)*	0.81*	0.56*
Female	163	90.1	63.4	76.7	0.53 (0.41-0.66)*	0.50*	0.56*
Age							
18-64	149	87.0	67.4	74.5	0.50 (0.37-0.63)*	0.75*	0.52*
>64	120	88.9	66.7	80.0	0.60 (0.46-0.74)*	0.60*	0.62*
Education Level							
<University	129	90.9	61.9	76.7	0.53 (0.39-0.67)*	0.69*	0.55*
≥University	138	87.8	70.8	76.8	0.54 (0.40-0.67)*	0.60*	0.56*

MVPA: moderate-vigorous physical activity; PA: physical activity
[a]Some participants not included in patient characteristic groups because information was missing/not reported.
[b]Number of participants that met predetermined criteria as outliers was 8. Analyses for patient characteristics include data from outliers.
[c]Patient-reported confidence reporting physical activity to the physical activity “vital sign”; dichotomized by 50th percentile of confidence scores on Likert scale of 1-5 where 5 was most confident. Low = 1-4; High = 5.
*$p < 0.0001$

Figure 4.2. Correlation and agreement of usual mins·wk^{-1} of an equivalent combination of moderate-vigorous physical activity (MVPA) assessed by the Physical Activity "Vital Sign" (PAVS) concurrently with a Modifiable Activity Questionnaire (MAQ), stratified by patient characteristic. Bland-Altman figures include 95% limits of agreement not adjusted for trend (column 2) and adjusted for trend (column 3). Larger plots signify multiple observations with same coordinates.

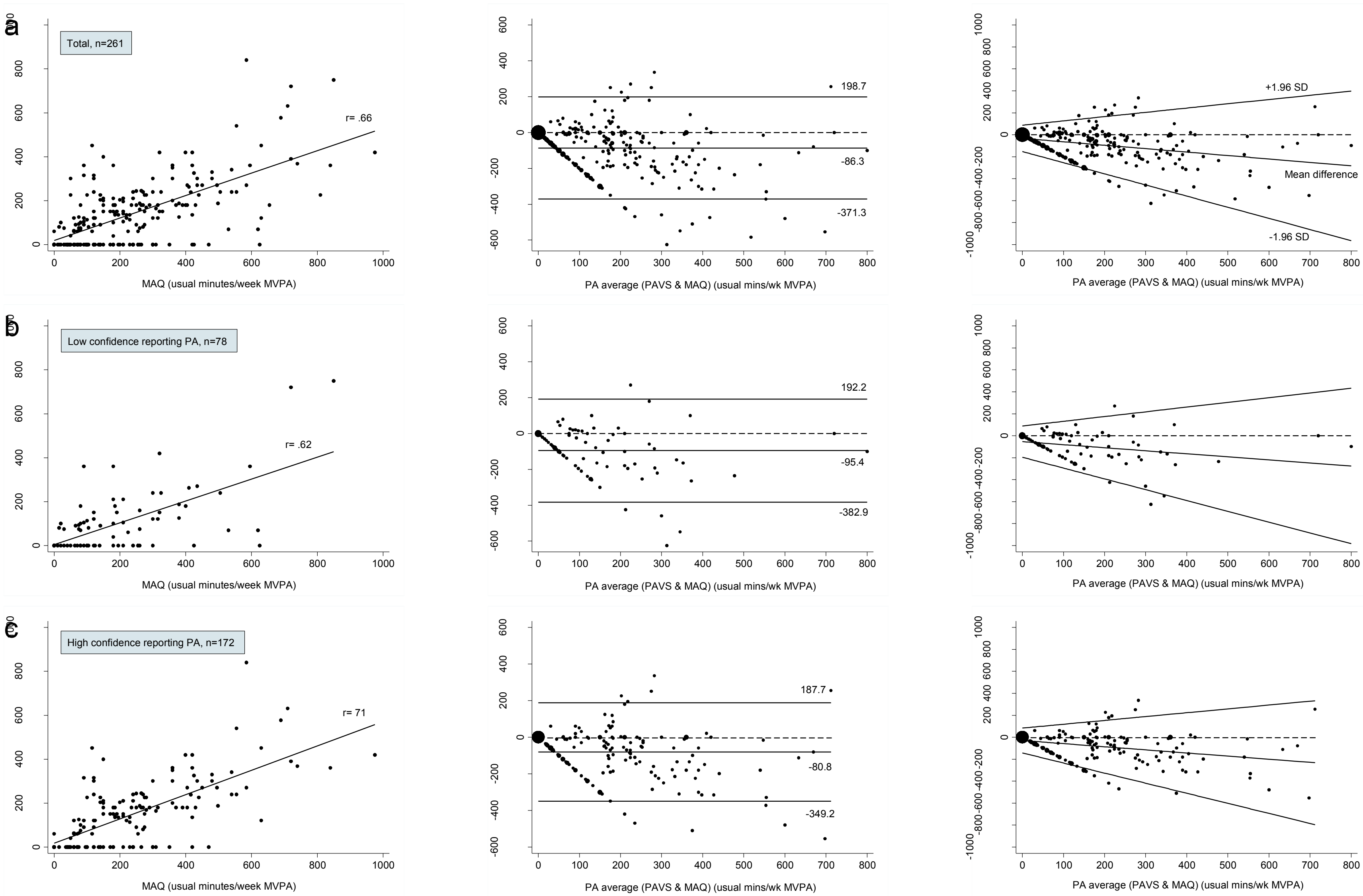
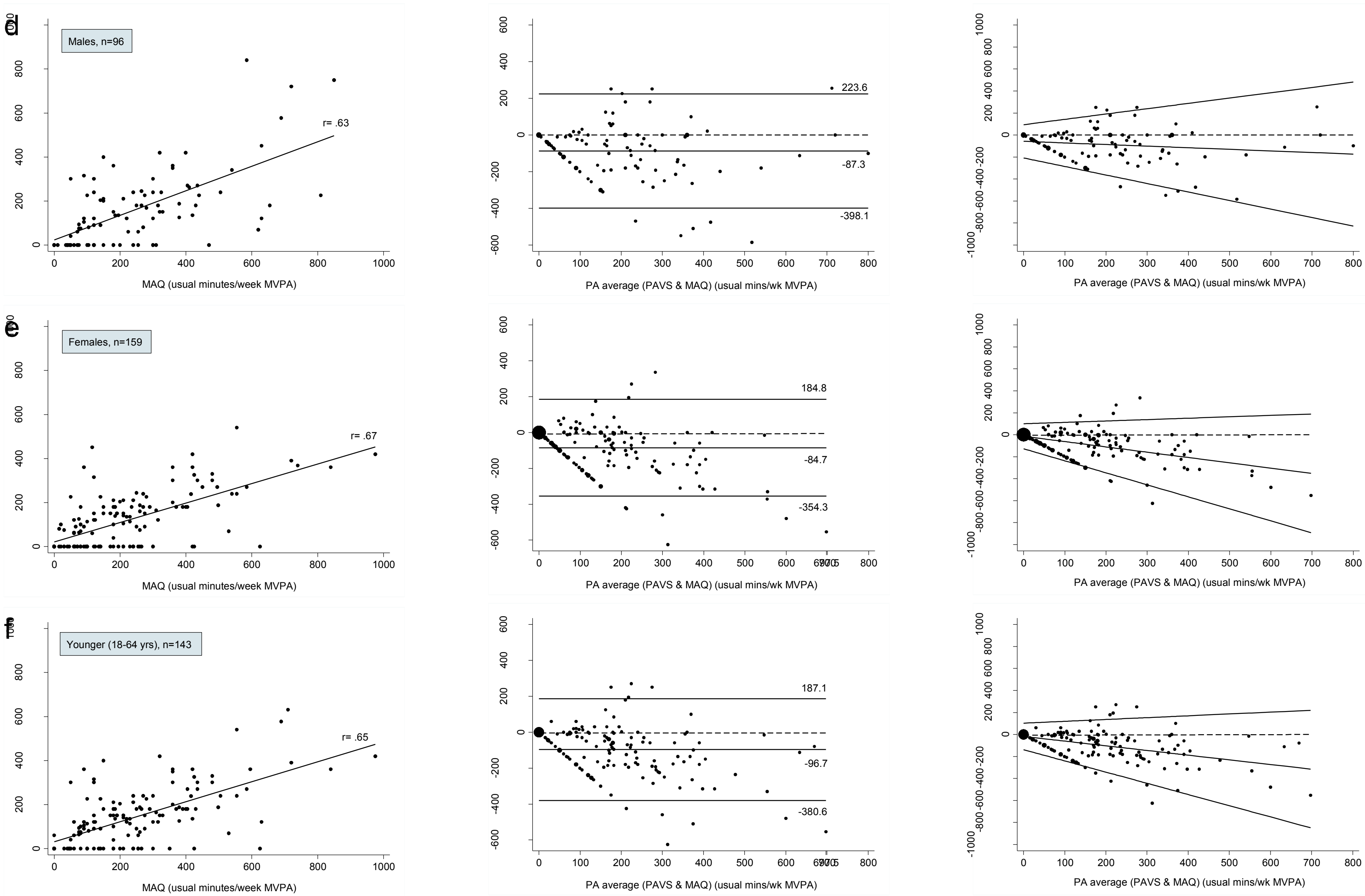


Figure 4.2 continued



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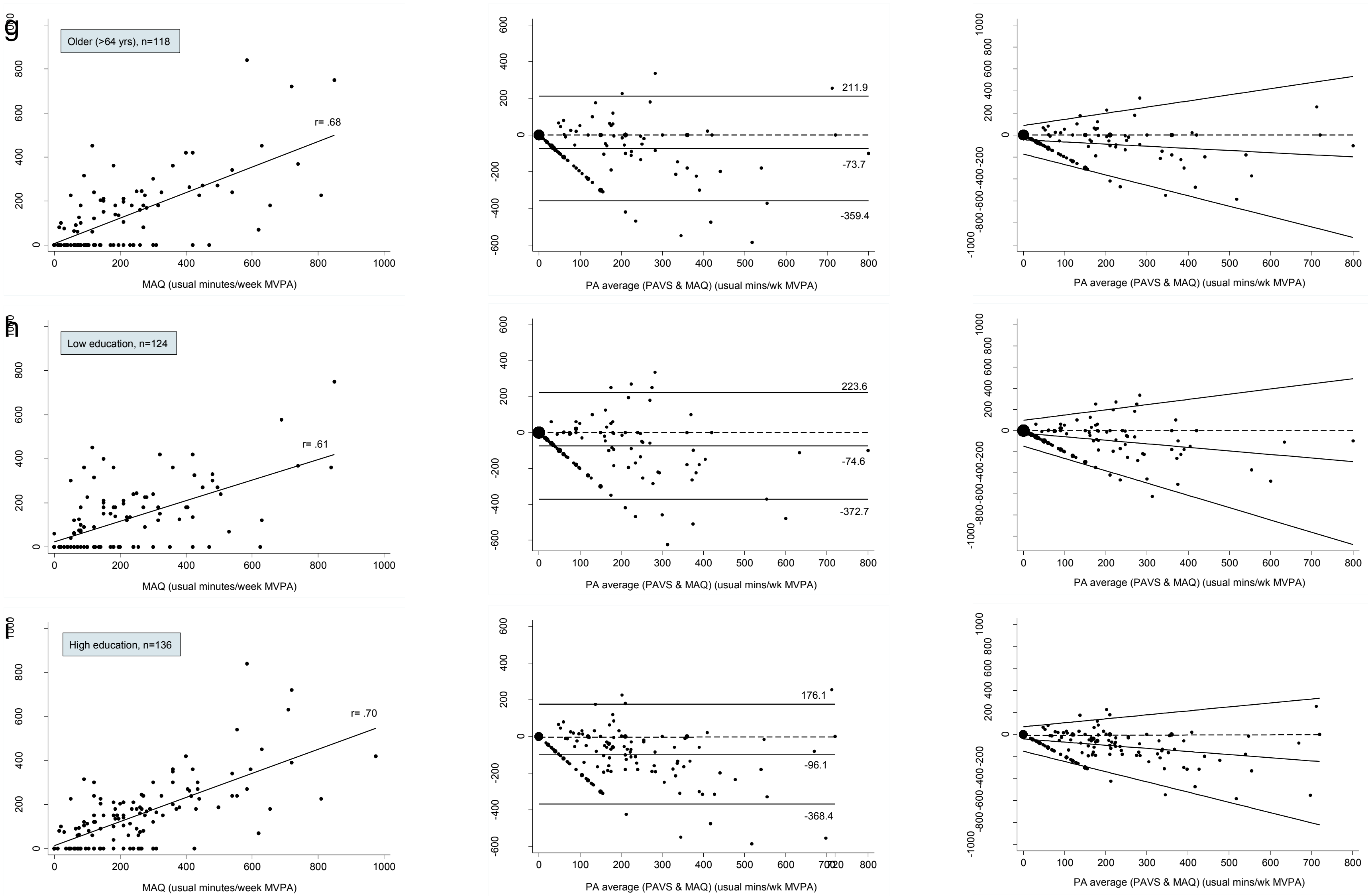

Figure 4.2 continued

Table 4.4

Ranked prevalence (%) of activities reported by patients to a Modifiable Activity Questionnaire by gender and age group.

		Gender		Age Group	
Activity	Total	Male	Female	Younger (18-64 yrs)	Older (>64 yrs)
Walking	66.6	75.7	60.3	70.4	61.8
Weights	24.6	31.3	20.1	27.8	20.6
Calisthenics	20.0	17.4	21.7	25.4	13.2
Elliptical	11.8	13.0	10.3	14.8	8.1
Jogging	10.5	13.0	8.7	17.2	2.2
Aerobics	10.5	3.5	15.2	13.0	7.4
Stationary Bike	10.5	12.2	9.8	8.9	12.5
Bike	6.2	7.0	6.0	8.9	2.9
Swim	5.9	10.4	3.2	7.1	4.4
Yoga	5.6	0.9	8.7	8.3	2.2
Hike	4.9	7.8	3.3	6.5	2.9
Dance	4.6	1.7	6.5	7.1	1.5
Gardening	3.6	7.0	1.6	3.6	3.7
Mow Lawn	3.0	6.1	1.1	1.8	4.4
Housework	2.6	0.9	3.8	1.8	3.7
Removing Snow	2.6	4.3	1.6	3.0	2.2
Stairs	1.6	0.9	2.2	2.4	0.7
Treadmill	1.6	0.0	2.7	2.4	0.7
Water Aerobics	1.6	0.0	2.7	0.0	3.7
Basketball	1.6	4.4	0.0	2.4	1.6
Pilates	1.3	0.0	2.2	1.8	0.7
Stretching	1.0	0.9	1.1	0.0	2.2
Loading Truck	1.0	2.6	0.0	1.2	0.7
Downhill Ski	1.0	0.9	1.1	1.2	0.7
Rowing	0.7	0.9	0.5	0.6	0.7
Zumba	0.7	0.0	1.1	0.6	0.7
Boxing	0.7	0.0	1.1	1.2	0.0
Cross-Country Ski	0.7	1.7	0.0	1.2	0.0
Moving Furniture	0.3	0.0	0.5	0.0	0.7
Trampoline	0.3	0.9	0.0	0.6	0.0
Sex	0.3	0.9	0.0	0.6	0.0
Roller Skating	0.3	0.0	0.5	0.6	0.0
Hockey	0.3	0.9	0.0	0.6	0.0
Rock Climbing	0.3	0.0	0.5	0.6	0.0
Kickball	0.3	0.0	0.5	0.6	0.0
Physical Therapy	0.3	0.0	0.5	0.6	0.0

Table 4.4 continued

		Gender		Age Group	
Activity	Total	Male	Female	Younger (18-64 yrs)	Older (>64 yrs)
Tennis	0.3	0.9	0.0	0.6	0.0

Note: Table includes only activities of moderate-vigorous intensity level according to activities included in a Modifiable Activity Questionnaire and according to activities patients reported as "other" when what they did was not already included in the Modifiable Activity Questionnaire. Activities in this table reported by patients as "other" are also only of moderate-vigorous intensity. This was determined by the Compendium of Physical Activities and energy expenditure estimated relative to each patient's age.[20]

CHAPTER 5

CONCLUSION

The PAVS is a brief assessment of patient PA that appears to have good criterion, construct and concurrent validity. The initial version of the PAVS that was used at The University of Utah health clinics and Community Health Clinics correlated moderately-strongly with accelerometry identifying days/week respondents performed at least 30 minutes of MVPA in bouts of at least 10 minutes ($r = 0.52$, $p < 0.001$). The PAVS used initially by Intermountain Healthcare predicted strongly patient BMI and disease burden categories (see Table 3.2). The association between the PAVS and the MAQ may be one of the strongest documented concurrent associations between two distinct self-report assessments of PA ($r = 0.71$, $p < 0.0001$). The PAVS correctly identified insufficiently active patients according to a MAQ nearly 90% of the time. The preeminent measurement property of a PAVS may be its ability to correctly identify patients who are insufficiently active according to PAG because this facilitates treating patients who most need counseling for physical inactivity.

Agreement between the most current version of the PAVS and the MAQ by Bland-Altman plots was only fair, including underestimating mins·wk^{-1} MVPA an average of 86.3 minutes. Although this discrepancy appears to highlight the PAVS as underestimating true usual mins·wk^{-1} MVPA, it is important to remember this was compared to another assessment of PA that was also self-report. In order to estimate better the ability of the PAVS to estimate mins·wk^{-1} MVPA, responses to the PAVS should be compared against a criterion or objective assessment of PA, such as by accelerometry or doubly labeled water.

Future evaluation of measurement properties of the PAVS should also include concurrent assessments that are repeated in order to assess the reliability of the PAVS. The existence of fewer reliability studies compared to validity studies suggest that it is common to forget that statistics commonly used to assess validity, or agreement between two methods, assume independence. This means, for example, associative and agreement findings of this study between the PAVS, EHR outcomes, and the MAQ represent only the population and samples included in analyses. Even if the PAVS agrees very closely to another method measuring the same traits of PA in patients, this agreement is limited by the repeatability of the PAVS as the PAVS is administered to the same patient at independent occasions. In order to assess further the agreement of the PAVS with criterion measures of PA, both the PAVS and other measures of PA need to be repeated.

Repeated agreement between the PAVS and criterion measures of PA will facilitate other investigations valuable to public health (see Figure 5.1). Repeated agreement of the PAVS will, for example, facilitate investigating PA-disease dose-response relationships using EHRs. Repeated agreement of the PAVS will also allow evaluating effectiveness of healthcare interventions aimed at improving PA because changes in patient PA will be reliable. It will be imperative to have assessments of PA in healthcare that are both valid and reliable in order to evaluate PA interventions in healthcare in ways similar to evaluating the effectiveness of pharmaceutical interventions.[1]

References

1. Vuori IM, Lavie CJ, Blair SN. Physical activity promotion in the health care system. *Mayo Clin Proc.* 2013;88(12):1446-1461.

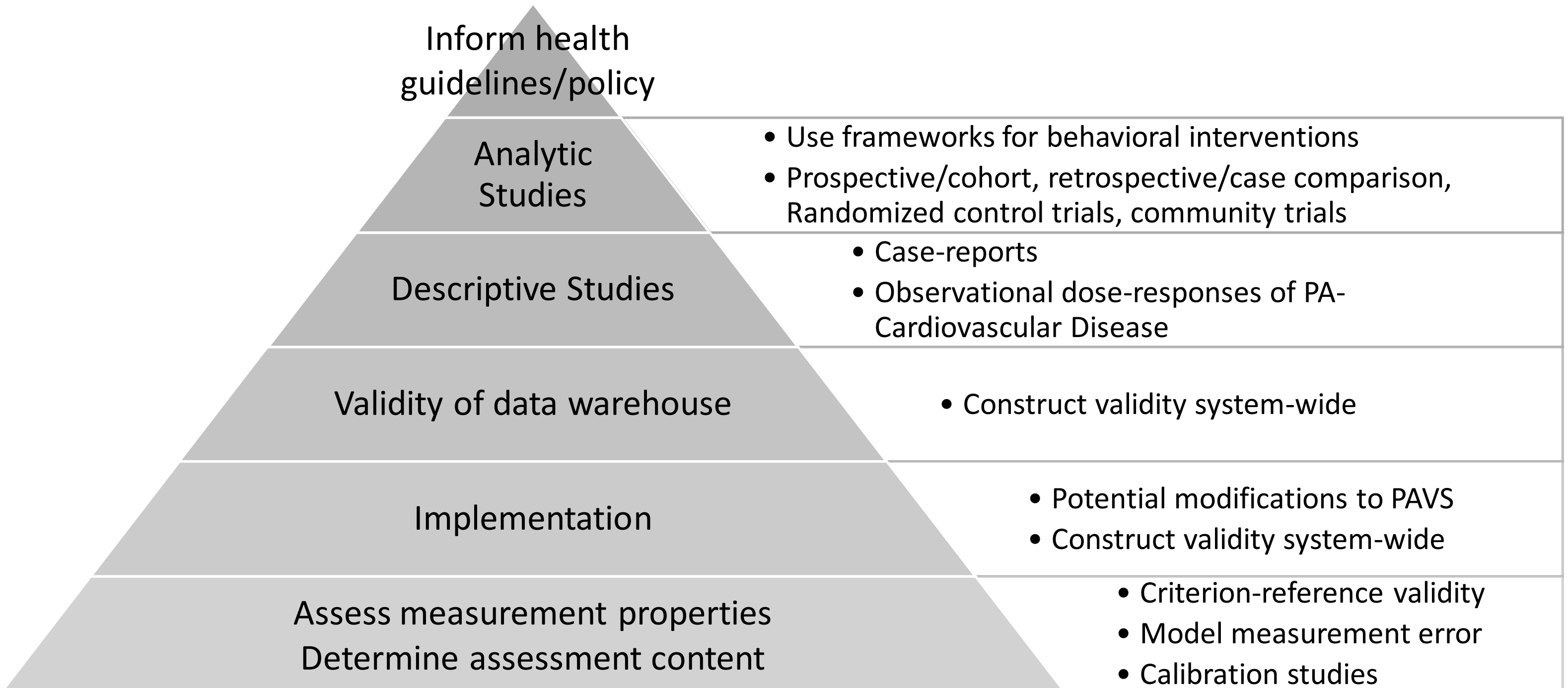

Figure 5.1. Steps for developing and using a patient-reported “vital sign” for PA. Bulleted items include next steps recommended based on findings from Chapters 2-4.

APPENDIX

MODIFIABLE ACTIVITY QUESTIONNAIRE

Male / Female Age_____ Provider____________ Clinic___________	**Highest education completed:** □ Some high school □ High school □ Tech college/other □ University	**Race/Ethnicity Information:** □ Latino/a or Hispanic □ Caucasian □ Asian/Pacific Islander □ African American □ Native American □ Do not wish to respond

Start Here:

① On a scale of 1 to 5, how accurate did you feel your response was when you reported your average levels of physical activity to the doctor, where 1 is "very unsure", and 5 is "very sure"?

1	2	3	4	5
Very Unsure	Quite Unsure	About 50/50	Quite Sure	Very Sure

② I'm going to mention a list of activities - please tell me *yes* or *no* to every activity you have done during the past 7 days. For each activity you did in the past 7 days, please tell me how many minutes you remember doing the activity per day (***emphasize 10-min bouts***).

Activity	**Total # Minutes per Day**						
from __________ to __________ day/date day/date	MON	TUE	WED	THUR	FRI	SAT	SUN
☐ Walking Briskly							
☐ Jogging							
☐ Calisthenics (sit-ups, pushups, etc.)							
☐ Hiking							
☐ Swimming							
☐ Bicycling							
☐ Aerobics							
☐ Tennis							
☐ Elliptical/EFX Machine							
☐ Weight Lifting							
☐ Mowing Lawn							
☐ Yoga							
☐ Dancing							
☐ Bicycling Machine							
☐ Basketball							
☐ Racquetball							
Other (write in below):							
☐							
☐							

☐ I did none of these activities over the past 7 days

③ Were these past 7 days reflective of your usual activity levels? ☐ YES ☐ NO

This is the END of the questionnaire. Thank-you for participating!

For Interviewer Only:

Check the box that best reflects the month in which the physical activity data was collected.

☐Jun – Aug ☐Sep – Nov ☐Dec – Feb ☐Mar – May

PAVS 1 ______

PAVS 2 ______

Light Moderate Vigorous

Note: mins·wk^{-1} MVPA for each patient that reported PA to the MAQ was calculated by summing all daily minutes reported doing any of all activities included with the MAQ. Minutes performing MAQ activities most commonly noted as “vigorous” according to the 2011 Compendium of Physical Activities were accounted twice when summing an “equivalent combination” of mins·wk^{-1} of moderate and vigorous PA. These activities included jogging, aerobics, basketball, and racquetball.